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# Bulletin

*of the*

# Torrey Botanical Club

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## CONTENTS

Controlled Differentiation in a Plant Tissue Culture ..... *Philip R. White* 507
The Genus Stereum in Pennsylvania ..... *L. O. Overholts* 515
The Development of the Embryo Sac and the Seed of Commelina angustifolia Michx. ..... *R. L. McCollum* 539
The Cytology of Apogamy in Pteris cretica Linn. var. albo-lineata Hort. ..... *Alphonse L. Heun* 549
A Brief History of Chinese Herbs and Medicine ..... *Leonard Chan* 563
Thiamin and Symbiosis ..... *William J. Robbins* 569
Index to American Botanical Literature ..... 573

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BULLETIN
OF THE
TORREY BOTANICAL CLUB

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# Controlled Differentiation in a Plant Tissue Culture

PHILIP R. WHITE

(WITH TWO FIGURES)

The attempt to grow isolated organs, tissues, or cells of animals or plants has as one of its objects the study of the cell in relation to its environment, including other cells and tissues of the organism. In providing an artificial environment capable of supporting normal survival and growth of the isolated tissue or organ, we are replacing the effects of the contiguous tissues by known and controllable factors. The question of whether or not the cultivated cells possess all the capacities of the entire organism does not necessarily arise. The cell need not be looked upon as totipotent.

If we are dealing not with single cells but with cell groups, as in fibroblast cultures or callus cultures, and if we are to assume that the metabolism of the individual cell is correctly represented in that of the mass, it is indeed essential that the culture shall not differentiate. While all somatic cells may in theory be looked upon as being totipotent elementary organisms, this totipotency must remain unexpressed if cultures of this kind are to be suitable for such studies. The importance of an undifferentiated body of cells in tissue culture work is thus evident and has received much emphasis in discussion to date. But, while it is important to be able to maintain cultures in an undifferentiated state in order that results may be interpreted, it is also highly desirable, at least from a theoretical point of view, to *know* how broad or how restricted are the real capacities of the cells in question, if they are totipotent or are restricted in their capacities. And, if their capacities are restricted, what is the degree and nature of this restriction?

The studies of animal organization carried on so extensively by the followers of Spemann lend considerable support to the point of view that the cell is totipotent, that its differentiation is, in the main, directed from

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outside the cell although the details of that differentiation are inherent in the organism. Studies of teratomas in general support the same concept. Animal fibroblast cultures, on the other hand, maintain their individualities for many generations and show only a restricted capacity of transformation to other cell types, to monocytes but not to epithelium, for example. These pure-line fibroblast cultures have for a long time represented one of the most serious stumbling blocks to acceptance of the concept of the cell as a "totipotent elementary organism." The root cultures carried on for the past decade in this laboratory and elsewhere have likewise failed to give evidence supporting the "totipotent" concept of the cell. Tomato roots have shown no sign of differentiating stem or leaf tissues nor of dedifferentiating to form simple parenchyma. They have always remained roots. They appear to be endowed with only a part of the capacities of the intact tomato plant, although they do form a considerable number of different cell types having different physiological functions. The callus cultures from the hybrid *Nicotiana glauca* × *N. langsdorffii*, maintained in this laboratory for the past year and a half and recently described (14), not only do not form organs but have actually formed only two types of mature cell—the very simple pith cell and the scalariform cell. These cultures might seem, therefore, to support the idea, which has become rather widely accepted in the last few decades, that there exists a definite and irreversible segregation of capacities among different regions and cells of any given organism.

It is the purpose of this paper to present evidence that this obvious interpretation of the behavior of these callus cultures is, in fact, fallacious and to show one way at least in which the totipotency of the tissues can be demonstrated.

## EXPERIMENTAL

Excised tomato roots ordinarily float at or near the top of the nutrient so that a large part of their surfaces lies not more than a millimeter or two from the air. Their supply of oxygen may be assumed to be quite adequate. When, as occasionally happens, roots do not float but sink to the bottom of the nutrient, they generally grow poorly, but it is not possible to say if this is the result of their sinking or if their submergence is itself evidence of low vitality. Whatever may be the primary limiting factor in this chain of events, the idea has grown up that, in order to obtain the best results with such cultures, it is desirable to give them a maximum contact with the air compatible with maintaining a satisfactory nutrient supply to the tissues. In cultivating callus masses of various

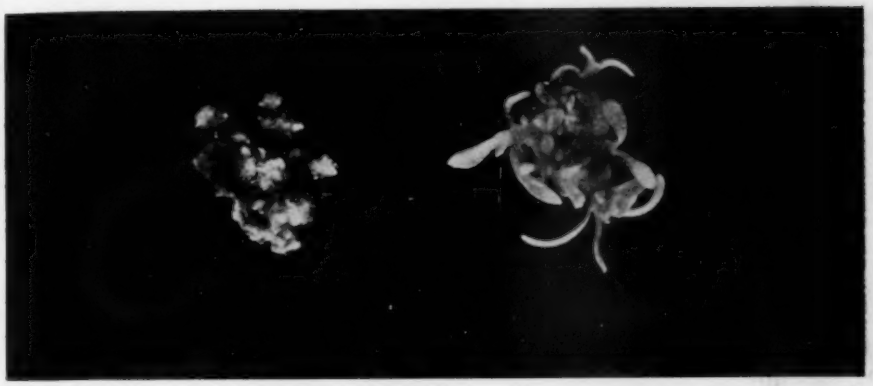

Fig. 1. Left: Callus culture undivided for 20 weeks, grown on a semi-solid culture medium. Right: A similar culture grown for 10 weeks on a medium like that at the left, then transferred for 10 weeks to a liquid medium containing the same nutrient materials. ×2.

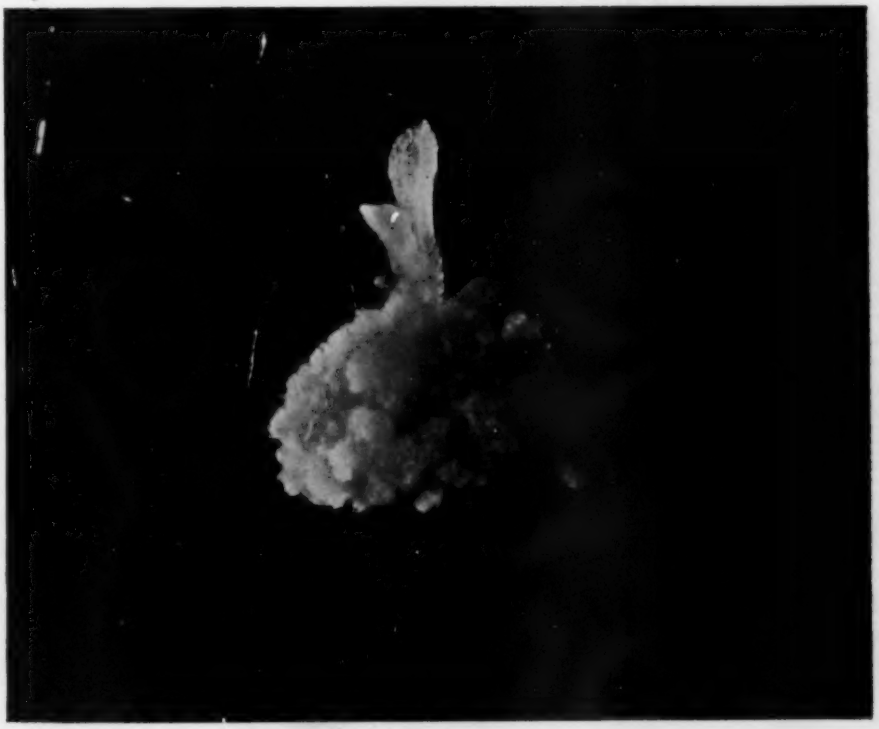

Fig. 2. A callus culture maintained for 8 weeks in an undifferentiated state by repeated transfer on a semi-solid nutrient and then placed for 2 weeks on a liquid nutrient. ×8.4.

kinds, Gautheret (2, 3) and Nobécourt (6) both found that growth occurred only in the portions of cultures which projected above the surfaces of the semi-solid substrata employed in their experiments. In attempting to cultivate callus in this laboratory, the solution developed for excised roots was first tested. Tissue fragments suitable for such cultures regularly sank to the bottom of the solution. To remedy this, a semi-solid nutrient capable of supporting the cultures was provided by adding 0.5 per cent of thoroughly washed agar to the above solution. Under these conditions a continuous, healthy-appearing callus growth was obtained without evidence of differentiation even after 20 or more weeks on such a substratum.

A few cultures, however, were reintroduced into the unmodified liquid medium with interesting results. Callus which had been maintained in an undifferentiated state by cultivation on a semi-solid medium for 10, 25, and 40 passages was allowed to stand in the liquid nutrient without being subdivided. After periods varying from 2 to 8 weeks, such cultures regularly underwent a marked transformation. Stem growing-points were differentiated at or near the surface of the cell masses. These developed into short stems, and typical small leaves were formed in exactly the manner so characteristic of these calluses when attached to the plant (figs. 1 and 2). It is well known that innumerable tiny leafy shoots regularly form on the callus overgrowths formed *in situ* (5). The shoots formed on excised callus when grown in liquid nutrient were entirely similar, with well formed green leaves and quite normal appearance.

Efforts to root leafy cuttings taken either from excised callus grown *in vitro* or from *in situ* callus have both so far failed. It is, therefore, not certain that these shoots possess all of the potentialities of the entire plant. It is, however, clear that they do possess a great many of these potentialities, far more than were evident in the undifferentiated callus cultures. In addition to the two types of cells formed on agar nutrients, these masses give rise, in a liquid nutrient, to mesophyll and palisade cells, epidermis bearing stomata and well formed glandular hairs, vascular strands, etc. They have not yet produced roots. This change in behavior has been brought about by the simple expedient of immersing the tissue mass under about 8 mm. of liquid instead of exposing it on the surface of the medium.

## DISCUSSION

What factor in this treatment is responsible for this change in behavior? The experiments carried out to date do not permit a definite

answer. The most obvious difference introduced is, as has been suggested, a difference of oxygen supply. When cultures are grown on nutrient agar, the air is in contact with a large part of their external surfaces and, through the open lacunae so evident in section (14, fig. 5), with a considerable proportion of the cells of the interior. Since photosynthesis presumably does not go on in these cultures, the gaseous exchange is merely that of absorbing oxygen and releasing $CO_2$. The characteristics of the culture and its surroundings permit this exchange to go on freely. Only in the interior of the cultures is there likely to be a deficiency of available oxygen, and it is precisely in the interior that the only differentiated cells, the scalariform cells, occur.

In cultures grown under a layer of liquid nutrient, these conditions of free gaseous exchange do not exist. Oxygen is but slightly soluble in water and in aqueous nutrients, and a sharp oxygen gradient exists between the liquid-air interface and the subsurface regions (15). The tissue, lying under about an 8 mm. layer of nutrient, is cut off from direct contact with the air and placed under conditions likely to result in an oxygen deficiency not only in the interior of the cell masses but at their surfaces as well. Bouillenne and Prevot (1) and Prevot (7, 8) have shown that anaerobic conditions favor the production of buds in *Begonia* and other plants. Priestley and his coworkers (9, 10) believe that pH gradients may be causally involved in the direction of meristematic activity. Lund and his school (11, 12) find that electropotential gradients are regularly associated with and greatly affected by conditions modifying the behavior of meristems. Both acidity and electropotential are, of course, largely influenced by respiration processes. There thus seems to be considerable evidence already in the literature to suggest that reduced oxygen supply may serve to orient the development of a tissue. The results of these experiments with excised plant callus fit satisfactorily into this hypothesis, although the evidence is as yet too meagre to permit a definite explanation.

Whatever the true explanation of this phenomenon may be, it is important to note that here we have taken groups of cells which for 10, 25, and 40 passages had appeared to have lost most of their capacity to differentiate, and by a very simple experiment have shown this appearance to have been false, to have been due merely to the conditions of the experiment. These cell groups are nearly, if not completely, "totipotent." They represent in a very real sense, "elementary organisms." We begin to get a glimpse into the mechanisms that control development. And these mechanisms, in this case at least, involve no complicated "hormone" con-

cept. We have produced caulices without "caulines," phyllices without "phyllocalines," just as in earlier work with roots we produced radices without evident "rhizocalines." Oxygen gradients, as long ago indicated implicitly by Rosene and Lund (11, 12) and others and as suggested by some of Thimann and Sweeney's recent work on cyclosis (13), may actually be responsible for many complex correlation phenomena.

SUMMARY

Cultures of callus from a hybrid *Nicotiana* which, on a semi-solid nutrient, have been maintained in an undifferentiated state through many passages can be made to form leafy branches of a high degree of differentiation by immersing them in a liquid nutrient. It is suggested that oxygen gradients may be important factors in controlling differentiation. Some of the implications of this observation for the concept of the cell as a totipotent elementary organism are briefly mentioned.

THE DEPARTMENT OF ANIMAL AND PLANT PATHOLOGY
THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH
PRINCETON, NEW JERSEY

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# The Genus Stereum in Pennsylvania[1]

L. O. Overholts

(with plates 14 to 18)

Among the wood-inhabiting fungi of Pennsylvania no species are more frequently encountered than the sessile members of the Family Thelephoraceae. Nor are the members of any genus more easily recognized on sight than are the members of the genus *Stereum*. Except for the species of Hymenochaete, almost any sessile or effused-reflexed fungus with smooth hymenium (i.e., no teeth, warts, gills, or pores) is safely referable to *Stereum*. Unfortunately, most of the wood-inhabiting species of the genus have the habit of growing in resupinate condition if the substratal surface is not conducive to pileus formation. The situation is similar to the relation one finds between the genus *Poria* and the genus *Polyporus* of the Polyporaceae. Fortunately, however, in most cases resupinate specimens of species of *Stereum* can be distinguished from such similar genera as *Corticium* and *Peniophora* by the presence of a cuticular layer (figs. 15, A and 16, A) of dense hyphae lying between the main body of the context and the substratum and connected to the latter by a loose tomentose layer. These two layers, tomentose and cuticular, are actually the representatives of the superficial pubescence and the layer from which it arises in the pileate condition.

A few species of *Stereum* are terrestrial and centrally or laterally stipitate (figs. 13, 14). Such are to be distinguished from *Thelephora* by the nearly or quite colorless tissue of the sporophore and the hyaline and smooth spores.

The hymenial structure of species of *Stereum* shows no outstanding characteristics not found in other genera of Higher Basidiomycetes. Cystidia or gloeocystidia are present in some species and when present show the usual variations found in similar groups. Vesicular cells (fig. 17) are present in a few species and paraphyses of diagnostic value are sometimes present. Structures of this sort can be demonstrated in crushed mounts of the tissue of the sporophores but are best seen in vertical sections, cut free hand, through the sporophore. In cutting such sections it is advisable to so orient the cuts that they are made parallel with the hyphal tissue of the pileus, i.e., in a radial direction. KOH is best used as a mounting fluid and the sections may be stained with phloxine or eosin.

[1] Authorized for publication on April 25, 1939, as paper No. 901 in the Journal Series of the Pennsylvania Agricultural Experiment Station. Contribution No. 121, Department of Botany, The Pennsylvania State College, State College, Pa.

In general spores are not easily obtained except from sections. Their small size and the fact that they are colorless renders their detection difficult unless present in abundance.

Burt lists about 80 species of the genus in North America. This includes a considerable number of tropical and subtropical species. A number of others are known only from limited ranges in various parts of the country. We have recognized 27 species occurring in Pennsylvania. Undoubtedly a few others will yet be found. The state has not been covered in any systematic fashion but collecting has been done in a considerable proportion of the counties. Fortunately, they are fungi that persist throughout the year and can be collected in at least fair condition winter and summer, although reaching the height of their development in late summer and autumn.

Economically the importance of the species lies in their wood-destroying propensities. They are among the most important wood-scavengers of the forest, attacking especially the sapwood of slash and stumps. Three or four species are of importance as heart-rotting organisms in living trees and in old logs. *Stereum gausapatum* has recently been shown to be of great importance as a heart-rot of sprout oak growth, and *S. sanguinolentum* is coming into prominence as a decay organism in living conifers. *S. frustulosum* produces a pocket type of heart-rot in chestnut and oak and *S. subpileatum* is of importance in a number of other hardwoods. All of the wood-inhabiting species are easily obtained in culture.

## GENERIC DESCRIPTION

Sporophore terrestrial or epixylous, stipitate, sessile, effused-reflexed, or largely resupinate, tough to leathery and somewhat woody; context white or somewhat colored but not darkening in KOH, usually bordered above by a definite narrow zone of compacted hyphae (cuticular layer) bearing the tomentum; hymenium inferior, even or nearly so; cystidia, gloeocystidia, vesicular cells, and prominent paraphyses sometimes present; setae none; spores hyaline or in a few cases tinted with age.

## KEY TO THE SPECIES IN PENNSYLVANIA

1. Sporophore stipitate, the stem central to lateral but not horizontal nor in the same plane with the pileus; growing on the ground ..... 2

   Sporophore sessile, effused-reflexed, or resupinate, rarely with a stem-like base in the same horizontal plane as the pileus; growing on wood ..... 3

2. Pileus 1–2 cm. broad, brown or hazel on drying; stem 2–4 mm. thick; pileus 200–300$\mu$ thick; spores ellipsoid or oblong, 4–5$\times$2–2.5$\mu$; cystidia numerous ..... *S. diaphanum*

   Pileus less than 1 cm. broad, drying pallid; stem about 1 mm. thick; pileus 400–800$\mu$ thick; spores subglobose, 4–4.5$\mu$ diameter; cystidia none ..... *S. Burtianum*

3. Sporophore small, convex or tuberculate, thick, cushion-shaped, not pileate, rarely as much as 0.5 cm. broad ..... 4

Sporophore sessile or effused-reflexed or if resupinate then either more than 0.5 cm. broad or else not convex nor tuberculate ..... 5

4. Sporophore red or reddish, waxy when fresh; on *Populus* only ..... *S. rufum*

Sporophore white or yellowish, hard and rigid when fresh; on *Quercus* and *Castanea* only ..... *S. frustulosum*

5. Context containing vesicular bodies, best seen in thin sections but usually discernible in crushed mounts ..... 6

Context not containing vesicular bodies ..... 8

6. Sporophore corky when fresh, hard when dry, rather thick, not bending without breaking ..... *S. Murrayi*

Sporophore coriaceous when fresh or when revived, often drying rigid but not hard ..... 7

7. With slender unincrusted cystidia 4–5$\mu$ diameter projecting from between the basidia ..... *S. rugosiusculum*

With subconical incrusted imbedded cystidia ..... *S. Pini*

Without cystidia ..... *S. purpureum*

8. Growing on wood of coniferous trees ..... 9

Growing on wood of deciduous trees ..... 17

9. Cystidia absent ..... 10

Cystidia present, not heavily incrusted ..... 12

Cystidia present, heavily incrusted in KOH ..... 16

10. Hymenium and context deep brown in color ..... *S. radiatum*

Hymenium and context pallid to gray or smoky ..... 11

11. Hymenial region soon layered by perennation ..... *S. rugosum*

Hymenial region not layered ..... *S. sanguinolentum*

12. Context (or subiculum) hyphae hyaline and more or less gelatinized; gloeocystidia present; cystidia colorless; growing only on small branches of *Pinus Strobus* ..... *S. Pini*

Context hyphae at least partly colored throughout; growing on logs and stumps of conifers; cystidia at least partly colored ..... 13

13. Cystidia scarcely or not at all projecting, short-cylindric or conic ..... *S. Chailletii*

Cystidia long-cylindric, protruding 50$\mu$ or more, though easily broken off at the surface of the hymenium ..... 14

14. Tissue becoming black in KOH, unchanged in $H_2O$ or lactic acid ..... *S. ambiguum*

Tissues not darkening in KOH ..... 15

15. Sporophore anise-scented when fresh, effused-reflexed ..... *S. rugisporum*

Sporophore not anise-scented, usually entirely resupinate ..... *S. abietinum*

16. Cystidia 8–12$\mu$ diameter, colorless ..... *S. sulcatum*

Cystidia 6–8$\mu$ diameter, brown ..... *S. Chailletii*

17. Incrusted cystidia present in the hymenium ..... 18

Cystidia if present not heavily incrusted ..... 23

18. Cystidia up to 10$\mu$ diameter ..... 19

Cystidia reaching diameters of more than 10$\mu$ ..... 20

19. Context and hyphae brown; no conspicuous paraphyses in the hymenium.... ..... *S. umbrinum*

Context and hyphae pallid or colorless; with aculeate paraphyses in the hymenium ..... *S. subpileatum*

20. Hymenium brown in mature specimens..... 21

Hymenium white, gray, smoky, or drab..... 22

21. Cystidia only up to 12$\mu$ diameter; spores 8–11×3–4.5$\mu$..... *S. albobadium*

Cystidia up to 16–20$\mu$ or more diameter; spores 5–7×2–3$\mu$..... *S. versiforme*

22. Sporophore less than 400$\mu$ thick (exclusive of tomentum); spores narrow-cylindric, 5–7×1.5–2$\mu$; all cystidia projecting only slightly, 40–50×15–20$\mu$.. ..... *S. erumpens*

Sporophore more than 400$\mu$ thick; spores 10–12×6$\mu$; some cystidia projecting 40–70$\mu$, 50–120×12–20$\mu$..... *S. cinerascens*

23. Narrow filiform paraphyses with antlered branching present in the hymenium; no cuticular layer present; young hymenium more or less lavender..... ..... *S. roseocarneum*

Without paraphyses; cuticular layer usually present..... 24

24. Conspicuous gloeocystidia present in the hymenium..... *S. fuscum*

Without gloeocystidia though narrow colored conducting hyphae may be present. 25

25. Cuticular layer lacking when vertical sections are examined..... 26

With a definite cuticular layer, usually appearing as a dense golden zone under the tomentum..... 27

26. Pileus strongly hirsute or tomentose; with inconspicuous cystidia that barely project above the level of the hymenium; on various hardwoods, seldom on *Carpinus* ..... *S. ochraceoflavum*

Pileus radiately silky-fibrillose; practically confined to *Carpinus*..... *S. sericeum*

27. Colored conducting hyphae numerous when thin unstained sections of the hymenium are observed; hymenium discoloring readily to dark red when wounded in fresh specimens ..... 28

Colored conducting organs few or none; the fresh hymenium not discoloring reddish ..... 29

28. Pileus tobacco-colored above, radially crisped and folded, villous to hirsute; hymenium region not zonate in sections..... *S. gausapatum*

Pileus whitish to grayish, not crisped nor folded, silky to tomentose; hymenial region becoming zonate..... *S. rugosum*

29. With very inconspicuous cystidia in the hymenium, these the same diameter as the basidia but projecting up to 15$\mu$; pileus with a soft white villous tomentum; hymenium bright yellow in fresh specimens..... *S. ochraceoflavum*

No cystidia; pubescence and hymenium coloration different..... 30

30. Pileus uniformly strigose-hirsute or hirsute-tomentose, gray, not crisped nor folded..... *S. hirsutum*

Pileus strigose hairy at the point of attachment, more glabrous or fibrillose-striate toward the margin, typically crisped and folded, more or less hazel at maturity ..... *S. rameale*

Pileus short-tomentose or villous-tomentose, not crisped nor folded..... *S. fasciatum*

SUPPLEMENTARY SYNOPSIS OF SPECIES

Stipitate species growing on the ground..... *S. diaphanum* and *S. Burtianum*
Sessile species, growing on wood

With non-incrusted cystidia only.....*S. abietinum*, *S. Chailletii*, and *S. ochraceoflavum*, the latter on hardwoods only, the two former on conifers only.
With heavily incrusted cystidia only
On coniferous wood.....*S. sulcatum*
On deciduous wood
Cystidia up to 10$\mu$ diameter.....*S. umbrinum* and *S. subpileatum*
Cystidia more than 10$\mu$ diameter.....*S. cinerascens*
With gloeocystidia only.....*S. fuscum* and *S. rufum*
With inflated thin-walled vesicular cells only.....*S. Murrayi* and *S. purpureum*
With colored conducting hyphae only
On coniferous wood.....*S. sanguinolentum*
On deciduous wood.....*S. rugosum* and *S. gausapatum* (occasionally *S. fasciatum*, *S. rameale*, and *S. hirsutum* would be sought here).
With paraphyses only.....*S. frustulosum* and *S. roseocarneum*
With both incrusted cystidia and branched or bottle-brush paraphyses
Cystidia not more than 12$\mu$ diameter.....*S. albobadium* and *S. subpileatum*
Cystidia 15–20$\mu$ diameter.....*S. versiforme*
With both vesicular cells and non-incrusted cystidia.....*S. rugosiusculum*
With both vesicular cells and heavily incrusted cystidia.....*S. Pini*
With no such sterile structures
On coniferous wood.....*S. radiatum*
On deciduous wood
Without a cuticular layer.....*S. sericeum*
With a cuticular layer
In section 200–300$\mu$ thick (exclusive of tomentose layer)..*S. ochraceoflavum*
In section 300–1000$\mu$ thick
Pileus hirsute.....*S. hirsutum*
Pileus tomentose.....*S. fasciatum*
Pileus radially fibrillose, strigose at base.....*S. rameale*

## DESCRIPTIONS OF SPECIES

### 1. *Stereum abietinum* Fries

Occasionally sessile with narrow pileus less than 1 cm. long, the surface brown or blackish brown, sulcate, uneven, tomentose, more frequently entirely resupinate, the hymenium at first brown with a pale margin, grayish-cinereous or with a purplish cast at the maturity of the spores, finally uniformly brown or blackish; in section 200–2000$\mu$ thick exclusive of the tomentose layer, not darker in KOH than in lactic acid, with a black cuticular layer and a broad context layer with hyphae 2–4$\mu$ diameter, next the cuticular layer these hyphae dark brown and horizontally arranged, curving into the pale hymenial region which becomes several layered with the old layers black, the annual hymenial layers 100–180$\mu$ broad; spores ellipsoid-elongate, then cylindric, 7–15$\times$3–4$\mu$; cystidia cylindric, reaching lengths of 300$\mu$, 6–10$\mu$ diameter, hyaline or nearly so on the projecting portion which may be as much as 60–80$\mu$ in length, brown below and in the older layers, thick-walled below, thinning out at the apex, sometimes slightly rugose but not incrusted.

On dead wood of coniferous trees. Although widely distributed in the eastern United States I have but a single Pennsylvania collection. This has the

hymenial color of *S. ambiguum* as illustrated by Litschauer (Archiv. f. Protist. 72: pl. 19, fig. 1). None of my other collections show this color which I take to represent a young stage. I take the failure of the tissue to blacken in KOH to be the best separating character between *S. abietinum* and *S. ambiguum* as pointed out by Burt. Two of the eight collections in my herbarium were identified and cited by Burt. Additional specimens are at hand from Ontario New Hampshire, Tennessee and Idaho.

2. *Stereum albobadium* (Schw.) Fries (fig. 6)

Largely or entirely resupinate, but sometimes with a narrow reflexed margin which is pubescent and brown in color, coriaceous, at first appearing in orbicular patches with hymenium even, velvety, dark brown, with a conspicuous white margin; in section 200–550$\mu$ thick, with no well developed cuticular and tomentose layers, the bulk of the context consisting of somewhat parallel and longitudinally arranged hyphae, 2–4$\mu$ diameter, brown-tinted; spores cylindric, smooth, hyaline, 7–10$\times$3–4$\mu$; cystidia rather abundant in the basidial layer, sometimes not conspicuous, projecting only slightly, 30–50$\times$8–12$\mu$ diameter, incrusted; branched paraphyses about 1$\mu$ diameter abundant in the basidial layer, rather conspicuous in young parts of the hymenium, more obscure when in fruiting condition, brownish.

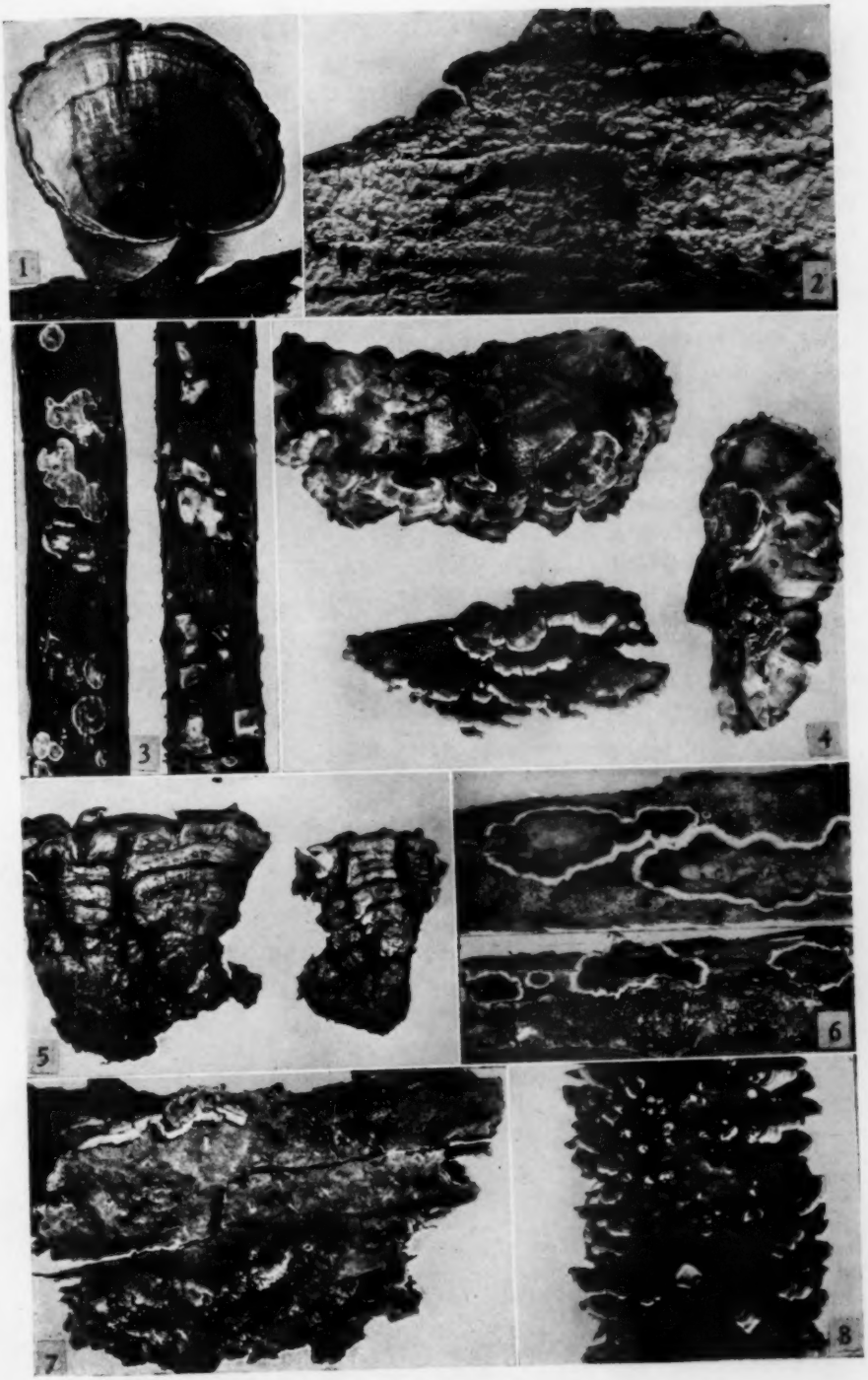
On dead wood of deciduous trees. The species seems to be rare in Pennsylvania, a single collection having been recorded. It differs from *S. versiforme* in the much smaller cystidia. Additional specimens are at hand from Tennessee, Georgia, Florida, Missouri and Idaho.

3. *Stereum Burtianum* Peck (fig. 14)

Sporophore stipitate, some specimens with circular and infundibuliform pileus, but mostly split down one side and broadly flabelliform or spathulate though never plane, occasionally multiparted, 1.5–2.5 cm. tall, the pilei less than 1 (rarely 2) cm. broad, thin and pliant, white to pale fox-colored above when fresh, drying brown or pale hazel but the margin usually remaining whitish, the surface marked with radiating fibers, the margin usually even; hymenium drying nearly pallid (said to be at first yellow), smooth; stem brown, finely velutinate, about 1 mm. thick, with a fox-colored mycelium on

**Explanation of Plate 14**

Fig. 1. *Stereum fasciatum*, atypical sporophore from top of log.
Fig. 2. *S. Murrayi.*
Fig. 3. *S. Pini.*
Fig. 4. *S. gausapatum.*
Fig. 5. *S. fuscum.*
Fig. 6. *S. albobadium.*
Fig. 7. *S. umbrinum.*
Fig. 8. *S. rameale.*




OVERHOLTS: STEREUM

the ground at its base; spores globose or subglobose, smooth, hyaline, 4–4.5$\mu$ diameter or 4×3$\mu$; cystidia and gloeocystidia none; in section 400–800$\mu$ thick, of parallel hyphae 2–3 diameter, septate; cystidia none.

On sandy banks in woods. Gregarious. July to September. Except for *S. diaphanum*, which differs widely in size, this is probably the only one of the soil-inhabting species that need be expected in Pennsylvania. Additional collections are at hand from Virginia, Tennessee and North Carolinia.

### 4. *Stereum Chailletii* Pers.

Usually resupinate, sometimes with a slightly reflexed margin up to 5 mm. broad, or the margin merely elevated and loosened, coriaceous, pale brown, becoming blackish, narrowly sulcate, tomentose; hymenium gray to pale brown, sometimes slightly tuberculate, even or slightly cracked on drying; in section 400–800$\mu$ thick, with a cuticular layer, a tomentose layer and a broad context, the latter composed of loosely arranged hyphae 2–4.5$\mu$ diameter, hyaline to chestnut-brown; spores ellipsoid-cylindric to cylindric, smooth, hyaline, 5–8× 3–3.5$\mu$; cystidia numerous in the hymenial region, brownish, rough-walled or lightly incrusted at the apex but incrustation dissolving in KOH, 5–8$\mu$ diameter, easily seen to be the termini of brown thick-walled hyphae of the context region.

On bark of various coniferous trees. A single collection has been made in Pennsylvania. Additional specimens are at hand from Ontario and Idaho.

### 5. *Stereum cinerascens* (Schw.) Massee (fig. 31)

Typically effused-reflexed but often almost entirely resupinate, the pileus less than 1 cm. long, coriaceous, gray to pale tan, hirsute-tomentose; context white or pallid; hymenium slightly pubescent under a lens, gray to smoky, even; in section 300–800$\mu$ thick (exclusive of the tomentose layer), with a definite cuticular layer, the context homogeneous, composed of closely interwoven horizontal hyphae 2–4$\mu$ diameter, becoming suberect in a narrow subhymenial zone, hyaline or dilute brown; spores at first ellipsoid, subcylindric at maturity, hyaline, smooth, 9–12 (–15)×5–7.5$\mu$; cystidia usually rather abundant, conical, limited to the hymenial region, some projecting up to 60$\mu$, others barely reaching the hymenial layer, heavily incrusted, hyaline or becoming brownish on the imbedded portion, 50–160×8–20$\mu$.

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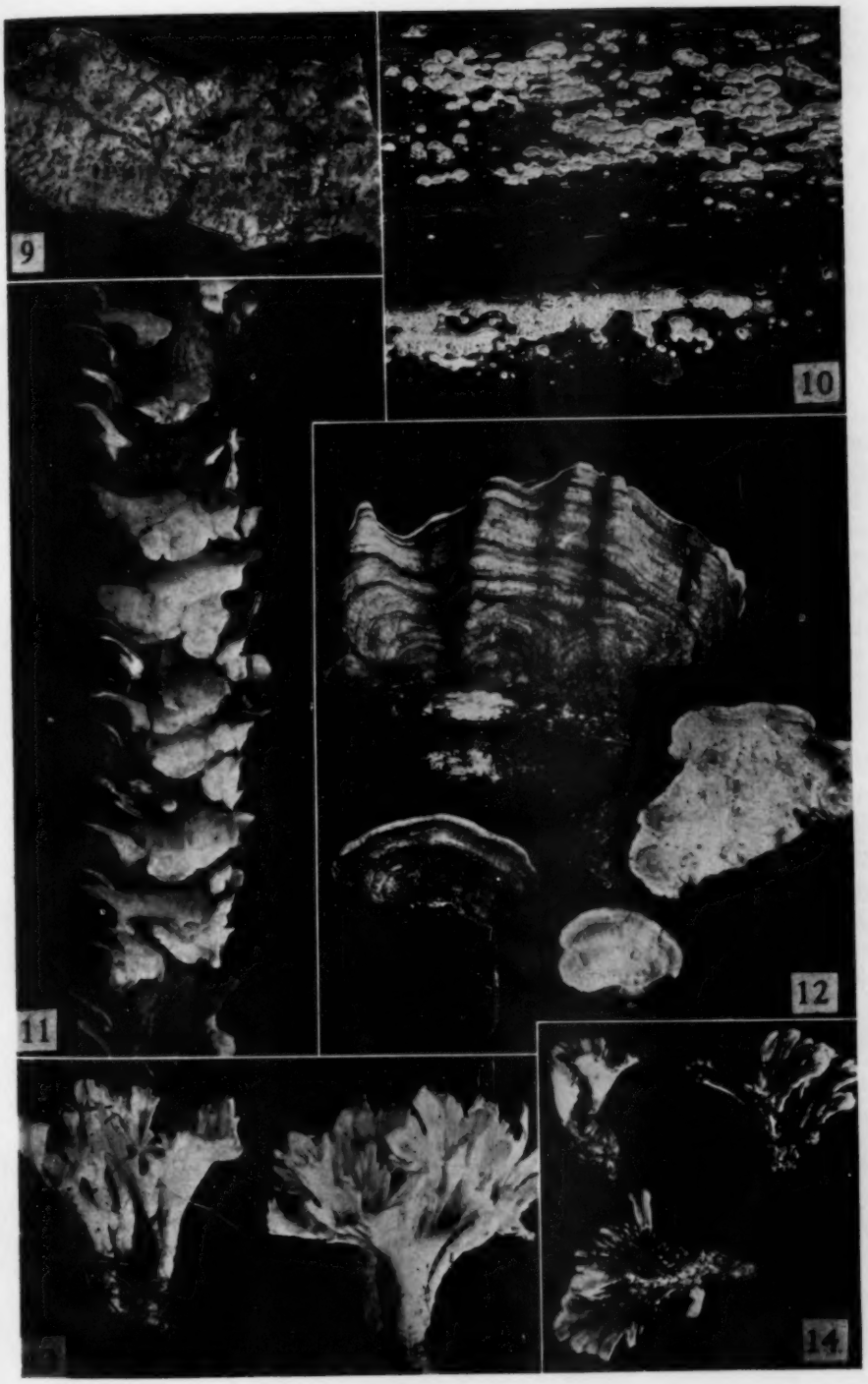
**Explanation of Plate 15**

Fig. 9. *S. rugosum.*
Fig. 10. *S. roseocarneum.*
Fig. 11. *S. sericeum.*
Fig. 12. *S. subpileatum.*
Fig. 13. *S. diaphanum.*
Fig. 14. *S. Burtianum.*




OVERHOLTS: STEREUM

On dead wood of deciduous trees. The species is distinct in the large incrusted cystidia and large spores. Additional specimens are at hand from Quebec, Vermont, New York, Minnesota and Nebraska.

6. *Stereum diaphanum* (Schw.) Cooke (fig. 13)

Growing singly and pileus 1–3 cm. broad or cespitose in clusters 3–5 cm. broad, stipitate, thin, tough and very flexible, entirely white or pale straw-color, depressed to infundibuliform, with margin entire or deeply split into spathulate or fan-shaped segments, fibrillose and sometimes crested on the upper surface; stem 0.5–2.5 cm. long, expanded upward, white-floccose or white-tomentose, 2–4 mm. diameter; in section 80–300$\mu$ thick, composed of closely compacted, hyaline, horizontal hyphae, 2–4$\mu$ diameter; hymenium white or light cream, more or less ridged or sometimes even in small plants; spores short-ellipsoid to oblong-ellipsoid, smooth, hyaline, 4–5$\times$2–2.5$\mu$; cystidia numerous, some scarcely projecting, others projecting up to 60$\mu$, 6–12$\mu$ diameter, with some crystalline material that dissolves in KOH, cylindric, blunt at apex.

On the ground in woods or on lawns under trees. This is one of but two ground-inhabiting species to be expected in Pennsylvania. It is rare, however. Additional specimens are at hand from Quebec, Ohio, Indiana and Missouri.

7. *Stereum fasciatum* Schw. (figs. 1, 29)

Sessile or effused reflexed, 2–8 cm. long, 2–6 cm. broad, less than 1 mm. thick, often laterally coalesced, thin and flexible when fresh, only partly rigid when dry, typically narrowly attached by a substipitate base but where effused-reflexed this not apparent, fan-shaped to dimidiate, rather a uniform gray in color but becoming darker and often greenish at the base, often reviving with marginal growth and then the second year's growth much lighter in color than that of the first year, more or less zonate and sometimes rather narrowly multizonate, covered by a thin compact tomentum which wears away exposing zones of hazel; context pallid to wood-color; hymenial surface gray to smoky or pale yellowish-tan, smooth and even; in section 600–1000$\mu$ thick,

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**Explanation of Plate 16**

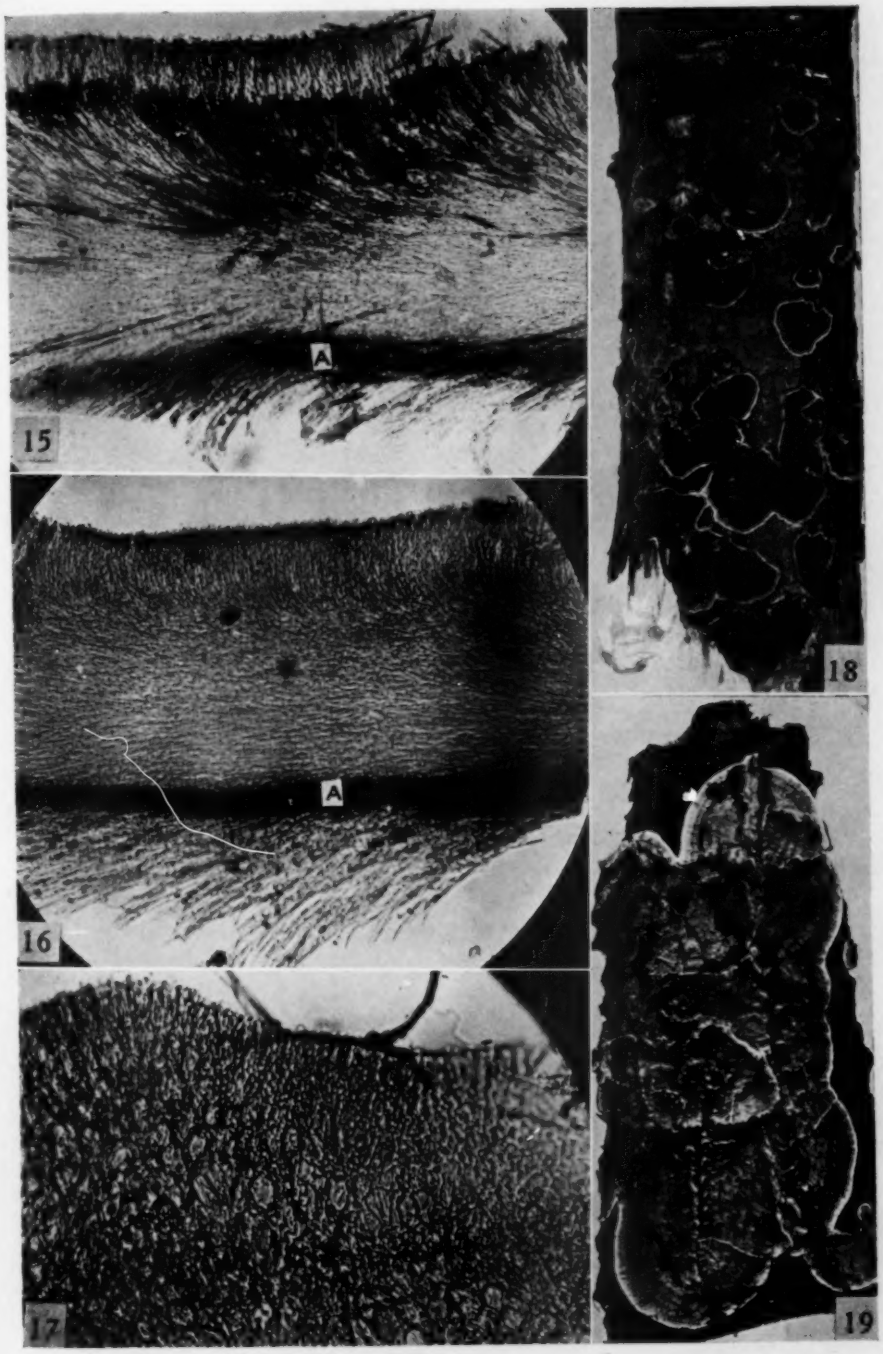
Fig. 15. *S. sanguinolentum.* Photomicrograph of vertical section through sporophore, showing the numerous dark colored conducting hyphae in the hymenial and subhymenial region and the cuticular layer under the superficial tomentum.

Fig. 16. *S. hirsutum.* Vertical section through sporophore, showing the well-marked cuticular layer bearing the superficial tomentum, and the broad context bearing the hymenial region.

Fig. 17. *S. Murrayi.* Vertical section through the lower part of the context, showing the subglobose vesicular cells.

Fig. 18. *S. versiforme.*

Fig. 19. *S. sanguinolentum.*




OVERHOLTS: STEREUM

showing a distinct tomentose layer, a definite narrow cuticular layer, and a broad context layer of practically colorless hyphae 3–4$\mu$ diameter, septate, compactly and horizontally arranged; spores subcylindric, smooth, hyaline, 5–7$\times$2.5–3$\mu$; cystidia none; with thick-walled hyphae in the basidial layer or in the subhymenial region and these traceable far back into the context.

On dead wood of deciduous trees, especially *Quercus*. This is a common and somewhat variable species, in general reaching larger sizes than most of the others. The species is important as a slash decay fungus working on the slash of large diameter. There are 95 collections in our herbaria from 19 states reaching from Maine to California and in Quebec and Ontario. Burt reports it from 38 states.

8. *Stereum frustulosum* (Pers.) Fr. (fig. 27)

Sporophores closely crowded on the substratum and forming a hard layer that appears to be broken up into units that are angular in shape, 1–6 mm. diameter, appearing as a layer of mud that has cracked into a multitude of small areas, the surface gray to whitish, entirely resupinate, separating into individual dry hard units; in structure typically about 1 mm. thick (occasionally 5–10 mm. thick), composed of erect closely compacted hyphae that are difficult to make out, more or less in annual layers; spores ellipsoid, smooth, hyaline, 5–6$\times$3–4$\mu$; bottle-brush paraphyses abundant in the hymenial region but not conspicuous, 4–5$\mu$ diameter.

On logs and stumps of *Quercus* and *Castanea*. Throughout the year. This is a common species, producing a pocket-rot of the wood in which the pockets are lined with white cellulose fibers. It inhabits the lower surfaces of logs in quite dry situations. Specimens are at hand from Nova Scotia, New Jersey, Maryland, North Carolina, Florida, Louisiana, Arkansas, Oklahoma, Missouri, Ohio and Indiana.

9. *Stereum fuscum* (Schrad.) Quel. (fig. 5)

Sessile, usually overlapping, sometimes much effused-reflexed, 0.5–2 cm. long, 2–5 cm. or more broad, uniformly tobacco-brown, more or less zonate and apparently renewing marginal growth yearly, compactly matted-tomentose, thin and flexible when fresh, drying brittle; hymenium white or isabelline, often pruinose-tomentose; in section 400–1200$\mu$ thick, no definite cuticular

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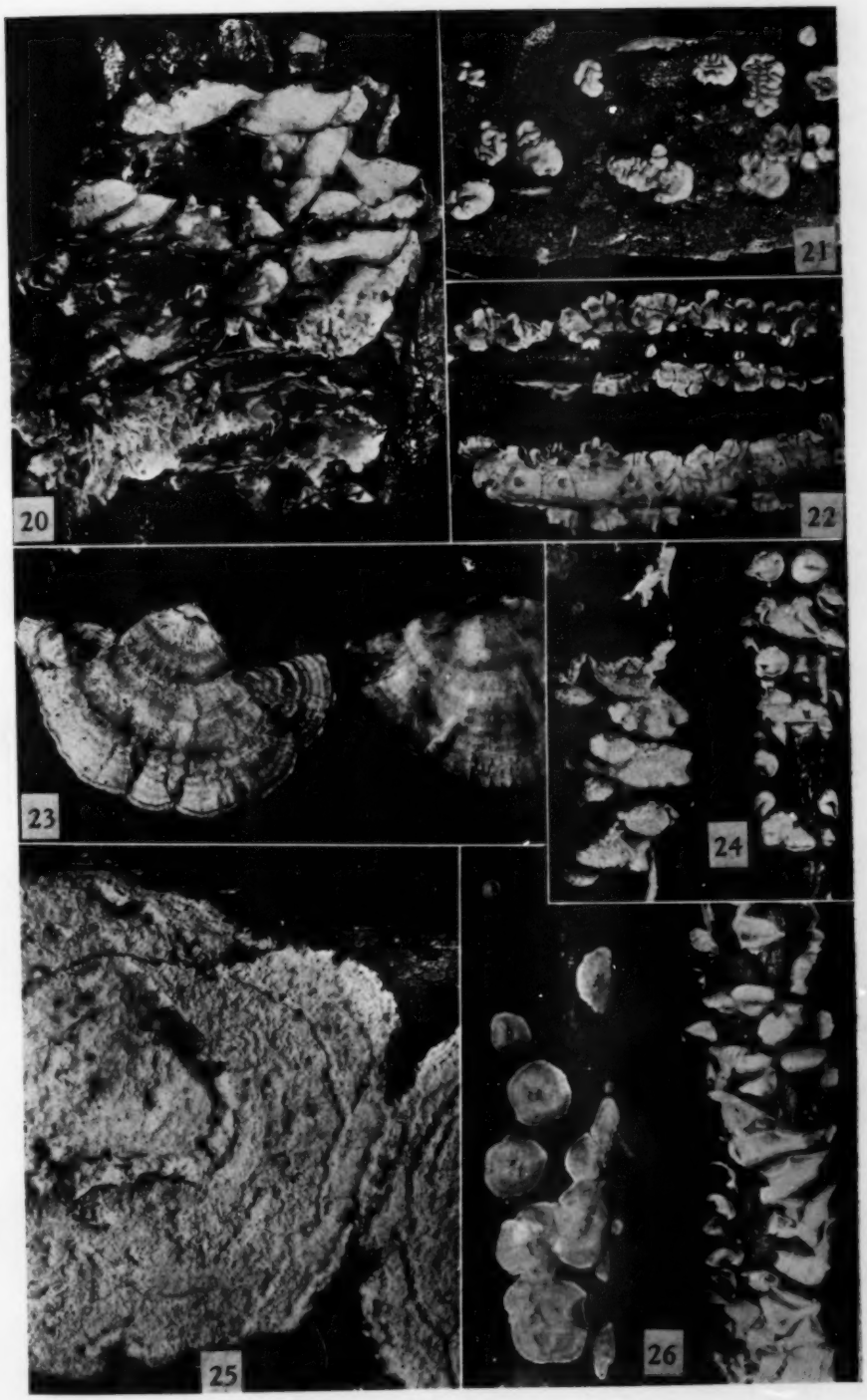
**Explanation of Plate 17**

Fig. 20. *S. purpureum.*
Fig. 21. *S. rufum.*
Fig. 22. *S. rameale.*
Fig. 23. *S. hirsutum.*
Fig. 24. *S. ochraceoflavum.*
Fig. 25. *S. sulcatum.*
Fig. 26. *S. sericeum.*




OVERHOLTS: STEREUM

layer, brownish or blackish-brown except in the hymenial and subhymenial region, composed of loosely arranged hyphae 3–5$\mu$ diameter, with clamps in the upper brown portion, the subhymenium of closely compacted hyaline hyphae 3–4$\mu$ diameter; spores ellipsoid, smooth, hyaline, 3–5$\times$2–3$\mu$; gloeocystidia as colored elongated organs, imbedded or projecting, tapering toward the apex, some brown in color and with divided content, 5–8$\times$60–100$\mu$.

On dead wood of deciduous trees. Throughout the year. A species easily recognized by the strong color contrast between upper and lower surface, and the thin tomentose pileus. Not common in Pennsylvania. Specimens are at hand from Ontario, Vermont, New Jersey, Maryland, Virginia, North Carolina, Georgia, Florida, Louisiana, Arkansas, Tennessee, Kentucky, Ohio and Indiana.

10. *Stereum gausapatum* Fries (fig. 4)

Sessile or effused-reflexed, tough and pliant when fresh, rigid when dry, overlapping, 0.5–2 cm. long, 1–2 cm. broad or laterally confluent to greater sizes, 0.75–1.5 mm. thick, pale yellowish-brown, hirsute, zonate or subzonate, usually crisped or folded; context pallid to smoky or pale brownish; hymenial surface smooth, pale brown and discolored darker on drying, the surface becoming dark reddish where wounded in fresh plants; in section 600–1000$\mu$ thick exclusive of the tomentose layer, the broad body of the context bordered on the upper side by a narrow cuticular layer 30–50$\mu$ broad supporting the broad tomentose layer, of compactly interwoven hyphae that are hyaline or somewhat colored, thick-walled, 4–7$\mu$ diameter; spores cylindric, smooth, hyaline, 6.5–7.5$\times$3$\mu$; colored conducting hyphae usually abundant in the hymenial and subhymenial regions, 5–7$\mu$ diameter, best seen in unstained sections.

On dead wood of deciduous trees, especially *Quercus*. This is one of the commoner species in Pennsylvania, especially on the sides of oak stumps not long cut, on which it grows profusely. It has lately been shown that it is the cause of an extensive and destructive heart-rot of living trees. The species is to be distinguished from *S. fasciatum* by the more densely hirsute and thicker pilei, while microscopically the presence of abundant colored conducting hyphae in the hymenial region is an important diagnostic point. Additional specimens are at hand from Connecticut, New York, New Jersey, West Virginia, North Carolina, Louisiana, Arkansas, Tennessee, Oklahoma, Missouri, Ohio and Manitoba.

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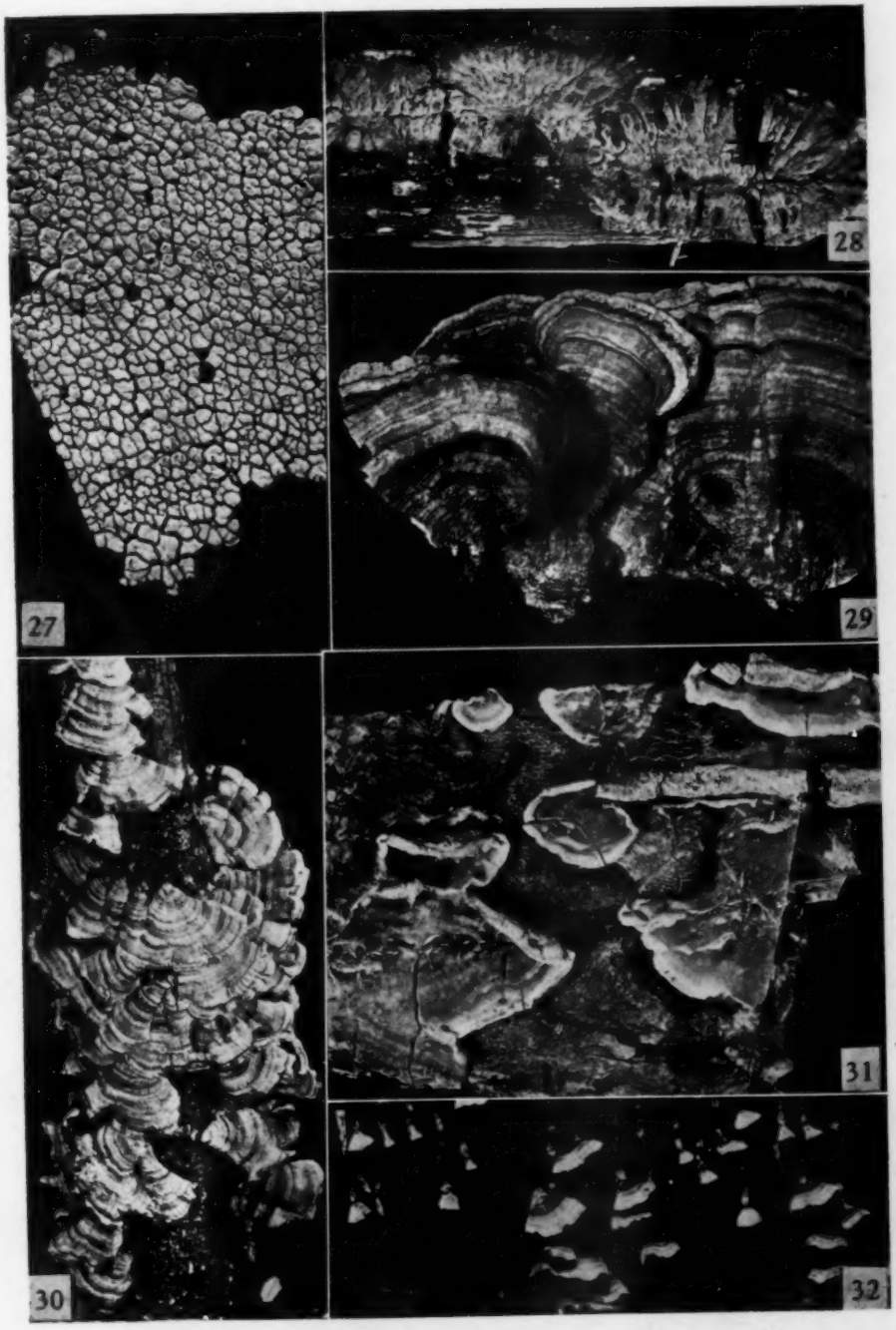
**Explanation of Plate 18**

Fig. 27. *S. frustulosum.*
Fig. 28. *S. radiatum.*
Fig. 29. *S. fasciatum.* Unusually larger sporophores.
Fig. 30. *S. rameale.*
Fig. 31. *S. cinerascens.*
Fig. 32. *S. rameale.*




OVERHOLTS: STEREUM

11. *Stereum hirsutum* (Willd.) Fr. (figs. 16, 23)

Sessile or effused-reflexed, tough and pliant when fresh, rigid on drying, hirsute or strigose, gray, zonate in larger specimens, 1–2 cm. long and broad or more narrowly reflexed; context pallid to brownish; hymenial surface pallid, in age gray-smoky; in section 450–1000$\mu$ thick (exclusive of tomentose layer), with a definite cuticular layer and a broad context with the main hyphae thin-walled and 4–5$\mu$ diameter, but in the subhymenial region with many thick-walled hyphae 5–8$\mu$ diameter that make up the hymenial region in young specimens and may contain a yellowish content; spores ellipsoid, smooth, hyaline, 5–7$\times$2.5–3$\mu$; cystidia none.

On dead wood of deciduous trees, usually on the smaller twigs and branches. Common in Pennsylvania. The species is to be distinguished from *S. fasciatum* by the hirsute pubescence, and from *S. gausapatum* in the lack of any considerable number of colored conducting hyphae, though in young specimens some of these structures may be present. The hymenium of this species does not discolor reddish where wounded as in *S. gausapatum,* but this point can only be verified in young growing plants. The general coloration here is gray on the pileus, while in *S. gausapatum* it is more brown or tan. Specimens are at hand from sixteen other states from Maine to Texas and California, and from Quebec, Ontario and British Columbia.

12. *Stereum Murrayi* (Berk. and Curt.) Burt. (figs. 2, 17)

Usually resupinate and widely effused, occasionally narrowly reflexed with a pileus as much as 1 cm. long and 1–5 mm. thick, uniformly coffee-brown then black, soon glabrous, zonate, hard and corky in texture; resupinate specimens usually with a narrow white swollen margin, the hymenial surface white or dirty-white, or in age darkening, typically much cracked into areas 2–5 mm. diameter and these with smaller cracks that break the surface into areas about 1 mm. diameter, usually rugose and uneven; in section not less than 500$\mu$ thick and usually much thicker, nearly colorless, without a cuticular layer, the context composed of densely interwoven hyphae about 2$\mu$ diameter along the substratum, 3–4$\mu$ above, and of many vesicular bodies of ovoid form 15–20$\times$10–12$\mu$, easily visible in crushed mounts; spores ovoid-ellipsoid, smooth, hyaline, 4–5$\times$2.5–3$\mu$; cystidia none.

On dead wood of deciduous trees but especially common on *Betula* and *Ostrya*. A common species in the mountainous regions of Pennsylvania, the favorite habitat being an old birch log. The hymenium is so rugose that the species is likely to be referred to the Hydnaceae. The abundant vesicular bodies are quite conspicuous if fairly thin sections through the sporophore are examined microscopically. Additional specimens are at hand from Quebec, Ontario, New Hampshire, Vermont, New York and West Virginia.

13. *Stereum ochraceoflavum* Schw. (fig. 24)

Sessile or effused reflexed, often thin and conical but typically dimidiate, 2–7(–10) mm. broad and long, white or gray, soft-hirsute or hirsute-tomentose; hymenial surface typically yellow to buff, in age more grayish; in section 200–300$\mu$ thick (exclusive of the broad tomentose layer), composed of compactly and horizontally arranged hyphae 3–4$\mu$ diameter, with an inconspicuous cuticular layer not well differeniated; hymenial layer composed of basidia and an inconspicuous type of cystidium scarcely broader than the basidia and projecting only slightly, at times their tips minutely mucronate; spores cylindric, smooth, hyaline, 6.5–7.5$\times$2–3$\mu$; no colored conducting hyphae.

On twigs and small branches of deciduous trees. A common species in Pennsylvania, typically easily recognized on its small size, the bright colored hymenium, and the white hairy pileus. It differs further from *S. hirsutum* in the thinner pileus, the much less definite cuticular layer (in section), and in the inconspicuous cystidia. It is especially common on small shrubs in fire-swept areas. Additional specimens are at hand from Ontario, New Jersey, North Carolina, Florida, Georgia, Louisiana, Tennessee, Kentucky and Minnesota.

14. *Stereum Pini* Fries (fig. 3)

Resupinate but finally with the margin free and attached only at the center, at first appearing as small orbicular patches 2–5 mm. broad, with a white fimbriate margin, then enlarging and thickening until the patches are 5–10 mm. diameter; hymenium at first pallid, soon dark gray or drab with a tinge of smoky lavender, finally avellaneous or darker; in section colorless or somewhat yellowish, 160–500$\mu$ thick, with a denser cuticular black narrow layer next the substratum, otherwise homogeneous, of closely compacted hyphae running vertically toward the center of ths sporophore but at the margins more horizontal, the walls somewhat gelatinously modified, this region containing some imbedded incrusted cystidia in the central part of the sporophore, and with scattered or rather numerous pyriform vesicular cells, these 15–36$\times$10–16$\mu$; incrusted cystidia also in the basidial layer, numerous or rare, projecting up to 20$\mu$, the incrustation slowly dissolving in KOH, 25–50$\times$5–10$\mu$; spores cylindric or allantoid, smooth, hyaline, 5–7$\times$1–2.5$\mu$.

On dead limbs of sapling *Pinus strobus* and occasionally on other species of *Pinus*. Rather common in central Pennsylvania, especially on small dead branches of saplings in pine plantations. The hymenium sometimes becomes somewhat pruinose and tuberculate under a lens, and specimens of that character were the basis for *Phlebia cervina* Overh. Apparently not a common species. Burt recorded its occurrence in but two states, Maine and New Hampshire. I have additional collections from Quebec, Ontario, Massachusetts and New York.

15. *Stereum purpureum* (Pers.) Fries (fig. 20)

Sessile or effused-reflexed, often imbricate, 0.5–3 cm. long and broad, often laterally confluent, up to 2 mm. thick, coriaceous when fresh, drying rigid and brittle, tomentose or villose-tomentose, with one or two concolorous zones, white to gray or avellaneous; hymenium dirty lavender to smoky-purple or in age smoky-isabelline, even; in section showing a fairly well differentiated cuticular layer, a broad tomentose layer typically thicker than the remainder of the section (1000–2000$\mu$ thick), and a broad dense context 500–800$\mu$ thick, the upper portion of the context layer loosely arranged, of more open hyphae 4–5$\mu$ diameter that bend into the hymenial region, this region of more open hyphae containing thin-walled pyriform to subglobose vesicular bodies 18–24$\mu$ diameter that are easily overlooked; spores cylindric, curved, 5–7$\times$2–3$\mu$; cystidia none.

On dead wood of various deciduous trees; perhaps occasionally on conifers. A well marked species, recognized by the typically purplish or smoky-purple hymenium coupled with a tomentose rather than hirsute pileus covering, and with vesicular bodies in the context. The tomentose layer reaches greater thickness than in any other species. This is the fungus to which is accredited the disease known as "silver leaf" that affects various species of trees, especially fruit trees. It is fairly common in Pennsylvania, and specimens are also at hand from Ontario, Maine, Vermont, Massachusetts, Connecticut, New Jersey, Virginia, Indiana, North Dakota, Washington and Oregon.

16. *Stereum radiatum* Peck (fig. 28)

Usually entirely resupinate but occasionally with a narrowly reflexed pileus that is blackish and velutinous on the upper surface, rather thick and coriaceous or somewhat cartilaginous; hymenium dark-brown to blackish-brown, typically with radiating ridges from the center, otherwise even; in section 400–500$\mu$ thick exclusive of the tomentose layer, brownish with a red tinge in lactic acid, becoming quickly green and finally decolorized in the hymenial region in KOH, with a cuticular layer, and a tomentose layer about as broad as the context layer that is composed of interwoven hyphae 3–4$\mu$ diameter, with clamps; spores cylindric, in age distinctly brown, 7.5–9.5$\times$3$\mu$; cystidia none.

On old coniferous wood, especially structural timbers. The species is rare in Pennsylvania, a total of five collections having been made. It is easily recognized by the brown hymenium with radiating ridges, the color change in KOH, and the largely resupinate habit. The color is rather unusual in *Stereum* and specimens are likely to be referred tentatively to Hymenochaete. Additional specimens are at hand from Quebec, New Hampshire, Michigan and Alberta.

17. *Stereum rameale* Schw. (figs. 8, 22, 30, 32)

Sessile or more often effused-reflexed and sometimes only narrowly pileate, if sessile usually fixed by a point and fan-shaped, spathulate, or dimidate in outline, reflexed sporophores more broadly attached, sometimes laterally confluent, 0.5–1 cm. or slightly more broad and long, thin and coriaceous when fresh, rigid when dry, the color an indefinite gray-cinnamon-buff, becoming more hazel as the thin layer of radiating fibers wears away, usually a bit strigose at the base, the margin often strongly crisped and folded, zonate and more conspicuously so with age; hymenium cinnamon-buff to ochraceous-orange; in section 300–750$\mu$ thick (exclusive of the tomentose layer), with a conspicuous cuticular layer under the pileus surface, the hyphae compactly arranged; spores cylindric, smooth, hyaline, 4–7$\times$2$\mu$; a few inconspicuous colored conducting hyphae are usually present in the hymenial layer; cystidia none.

On dead wood of deciduous trees, usually on rather small twigs and branches. A common species in Pennsylvania, usually easily recognized by the small size, the zonate and fibrillose-striate pileus that becomes bay or hazel in age, and the fairly bright-colored hymenium. From *S. ochraceoflavum* with which it agrees in size it is to be distinguished by the less conspicuous pileus covering, the more zonate pileus, and the typically less brightly colored hymenium. It is one of the important slash decay fungi in the deciduous forest. Burt reports it as occurring throughout the United States and I have collections from 18 states from Maine to Georgia and west to Texas and Colorado.

18. *Stereum roseocarneum* (Schw.) Fr. (fig. 10)

Sporophore typically resupinate, sometimes with a narrow reflexed margin 1–2 mm. wide and this violaceous-gray to pale-buff, tomentose; hymenial surface pale gray-lavender to lilac-lavender but finally fading, usually becoming cracked; in section 300–500$\mu$ thick, without a cuticular layer, the context homogeneous, with loosely interwoven, thick-walled hyphae 3–4$\mu$ diameter; spores ellipsoid, smooth, hyaline, 6–9$\times$4–6$\mu$; cystidia and vesicular bodies none; narrow paraphyses with antlered branching, 1–2$\mu$ diameter present between the basidia.

On dead branches of various deciduous trees, or on decorticated wood, fence-rails, etc. The violaceous or lavender hymenial color coupled with the practically resupinate habit is usually enough to identify this fungus, although the branched paraphyses constitute an additional diagnostic feature. Because of the resupinate habit and the lack of a cuticular layer this species will perhaps often be sought in Corticium. It is rather common in Pennsylvania, and other specimens are at hand from Newfoundland, Quebec, New Hampshire, Vermont, New York and Massachusetts.

19. *Stereum rufum* Fries (fig. 21)

Sporophore tuberculose, erumpent, 2–5 mm. diameter, rather waxy-fleshy, 1–2 mm. high, circular in outline, convex to plane; hymenium strongly rugose at maturity, wine-colored to reddish, pruinose at maturity; in section composed of ascending or erect, incrusted, hyaline hyphae 4–5$\mu$ diameter, rather compactly interwoven; spores allantoid, smooth, hyaline, 6–7$\times$2–2.5$\mu$; gloeocystidia abundant in the basidial or subhymenial layer, not projecting, filled with a dense granular material, 7–15$\mu$ diameter, the apex pointed or obtuse; cystidia none.

On dead *Populus tremuloides*. Not common in Pennyslvania but occasionally collected. One of the easiest of the stereums to recognize once located in the proper genus. It is more or less aberrant in the genus, however, because of its form and the lack of a definite pileus. The species is widely distributed over the northern United States and Canada, and additional specimens are at hand from Ontario, Manitoba, New Hampshire, New York, Vermont, North Dakota, Montana, Colorada and New Mexico.

20. *Stereum rugosiusculum* Berk. and Curt.

Sessile or effused reflexed, 1–2 cm. broad and long, flexible when fresh, usually imbricate and laterally connate, densely hirsute-tomentose, zonate, gray to grayish black; hymenial surface smooth or rugose, smoky-lavender to fleshy-lavender or fleshy-brown; in section 500–600$\mu$ thick exclusive of the tomentum, with a tomentose layer, a cuticular layer, and a broad context layer, the latter of thin-walled hyphae with abundant clamps, 3–4$\mu$ diameter, with few or many pyriform vesicular cells imbedded in the subhymenial region; spores cylindric, hyaline, 5–6$\times$2.5–3$\mu$; cystidia scattered, cylindric, hyaline, sometimes slightly incrusted, 4–6$\mu$ diameter, projecting 20–40$\mu$.

On dead wood of deciduous trees; occasionally on coniferous wood. Not common in Pennsylvania. From *S. purpureum* this species differs mainly in the presence of cystidia. Widely distributed in the United States. Additional specimens are at hand from Vermont, New Jersey, Idaho and British Columbia.

21. *Stereum rugosum* (Pers.) Fries (fig. 9)

Typically resupinate, sometimes narrowly reflexed and with pileus whitish to gray and sulcate, pubescent to hirsute, becoming glabrate, 1–10 mm. long and broad when reflexed; hymenium cream-color or with livid tinge, changing to red when wounded, darkening with age, even, sometimes slightly cracked on drying, in section 400–800$\mu$ thick, with a cuticular layer, the context hyphae densely interwoven, 4–5$\mu$ diameter, thick-walled, more or less colored in age, the hymenial region soon layered by perennation, though the layers usually indistinct, each with numerous colored conducting organs 4–6$\mu$ diameter; spores cylindric, 6–10$\times$2.5–4$\mu$; cystidia none.

On dead wood of deciduous trees; occasionally on conifers. A species easily confused with *S. gausapatum* and *S. sanguinolentum,* from both of which it is presumed to be distinct in the two-many layered hymenium. The color and pubescence is scarcely that of either species. Rare in Pennsylvania. Additional specimens are at hand from Newfoundland, Quebec and New Hampshire.

22. *Stereum sanguinolentum* Alb. and Schw. (figs. 15, 19)

Sessile or effused-reflexed, coriaceous when fresh, 2–10 mm. broad and long, gray, villous or silky-tomentose, azonate; in section 350–500$\mu$ thick exclusive of the tomentose layers, with a narrow but definite cuticular layer and a broad context, the latter often brownish in color, composed of horizontally arranged hyphae 3–3.5$\mu$ diameter, and in the subhymenial region with few to many dark-brown conducting hyphae 4–6$\mu$ diameter that end between the basidia; hymenium gray to smoky, when fresh exuding a red juice or discoloring red where wounded, even; spores cylindric, hyaline, 5–8$\times$2–3.5$\mu$; cystidia none.

On dead wood of coniferous trees, usually of *Tsuga,* occasionally on others. Rather common in Pennsylvania. This species causes a serious decay of hemlock. Additional specimens are at hand from Newfoundland, Quebec, Ontario, Maine, Vermont, New Hampshire, Massachusetts, New York, Tennessee, Colorado, Idaho and British Columbia.

23. *Stereum sericeum* Schw. (figs. 11, 26)

Sessile or effused-reflexed, typically attached by a point and spathulate to fan-shaped in outline, very thin and coriaceous when fresh, 1–1.5 cm. broad and long, or smaller, whitish or gray, silky with minute radiating fibrils, not folded nor crisped; in section 200–300$\mu$ thick, no cuticular layer and no definite tomentose layer, composed of densely arranged horizontal hyphae 3–4$\mu$ diameter; hymenium smooth, pallid to wood-color; spores subcylindric, smooth, hyaline, 6–8$\times$2.5–3$\mu$; cystidia and colored conducting organs none.

On dead wood of *Carpinus;* rarely on other substrata. The species is very common on *Carpinus* in Pennsylvania. It can be recognized usually by the substratum, the pallid pileus marked with minute radiating fibrils and very thin. It differs from *S. fasciatum* internally in the lack of cuticular and tomentose layers. Additional collections are at hand from Ontario, New York, New Jersey, Tennessee, Georgia, Florida, Ohio and Indiana.

24. *Stereum subpileatum* Berk. and Curt. (fig. 12)

Resupinate, sessile, or effused reflexed, pileus 0–3(–5) cm. long, 1–4 cm. wide, 1–2(–4) mm. thick, hard and rigid, the surface concentrically sulcate and zoned with narrow zones that finally become glabrous and blackish, tomentose, brown, with a rather distinct black line representing the cuticular layer

under the tomentum; hymenium even, bright cinnamon to somewhat buff, in section 1000$\mu$ or more thick, with a broad tomentose layer, a black cuticular layer, and a broad context layer, the hyphae of the latter densely and horizontally arranged, 3–4$\mu$ diameter, bearing the hymenium which becomes layered by perennation; spores ellipsoid, smooth, hyaline, 4–5$\times$2.5–3$\mu$; cystidia present, cylindric, incrusted, 6–8$\mu$ diameter, in the older layers becoming somewhat brownish, and indistinct, the incrustation dissolving in KOH; paraphyses of the bottle-brush type, sometimes few and indistinct, 3–5$\mu$ diameter.

On dead and down logs of *Quercus* and more rarely on other substrata, particularly *Liquidambar*. In its substrata it produces a pocket type of heart-rot similar to that caused by *S. frustulosum*. The fungus reaches its northern limit of distribution in southern Pennsylvania. I found it to be abundant in Louisiana on both *Quercus* and *Liquidambar*. The rotted wood when freshly opened up has a sweet honey-like odor and the fungus in culture is decidedly odorous. *S. sepium* Burt is certainly a synonym and *S. insigne* Bres. has been referred to synonym here. The more abundant the cystidia the fewer the paraphyses that are present, and vice versa. Additional specimens are at hand from New York, New Jersey, Florida, Louisiana, Arkansas, Tennessee and Missouri.

### 25. *Stereum sulcatum* Burt. (fig. 25)

Entirely resupinate or with a narrow blackish reflexed pileus or a tumid margin, coriaceous or leathery in texture, drying rather hard; hymenium typically with a beautiful ruddy tinge when fresh and becoming darker red where bruised if in fresh condition, roughened and tuberculate and sometimes with concentric ridges; in section 600–1000$\mu$ thick (more over the tubercles), more or less colored, with a tomentose layer, a narrow dark cuticular layer, and a slightly colored broad context layer of closely woven and subhorizontal hyphae 2.5–4$\mu$ diameter, the hymenial region becoming stratified by perennial growth and the elements there erect and very compact; spores broadly ellipsoid or subglobose, smooth, hyaline, 5–6$\times$4–5$\mu$ or 4–5$\mu$ diameter; cystidia numerous, imbedded in the tissue or somewhat projecting, incrusted, 25–40$\times$7–12$\mu$.

On dead wood of coniferous trees. This species is rather common in the mountainous region of central Pennsylvania. There is some resemblance to *Stereum Murrayi* but the ruddy hymenium, the presence of cystidia, and the absence of vesicular cells in the context, as well as the coniferous substratum, furnish ample diagnostic characters. Specimens are at hand from Ontario, New Hampshire, Tennessee, Colorado and Idaho.

### 26. *Stereum umbrinum* Berk. and Curt. (fig. 7)

Resupinate or becoming only slightly reflexed with pileus less than 1 cm. long but nearly always entirely resupinate with a paler margin, coriaceous,

the hymenial surface lavender or purple when young and growing, soon changing to dark brown, even; in section 300–1000$\mu$ thick, homogeneous and without a cuticular layer, composed of loosely interwoven, pale brown hyphae 3.5–4$\mu$ diameter, with some cross walls but no clamps; spores oblong or oblong-ellipsoid, smooth, hyaline, 6–7$\times$3.5–4$\mu$; cystidia scattered or rather numerous, only in the hymenial or the subhymenial region, projecting up to 50$\mu$, with a thin incrusting layer, colored slightly brownish except where exposed, 6–10$\mu$ diameter.

On dead wood of deciduous trees, especially *Quercus*. A beautiful species when in its prime and then easily recognized, but soon discoloring brownish. The cystidia and the open context hyphae are additional diagnostic characters. Additional specimens are at hand from Connecticut, Virginia, Georgia, Florida, Mississippi, Louisiana, Tennessee, Illinois, Missouri and Iowa.

27. *Stereum versiforme* Berk. and Curt. (fig. 18)

Usually entirely resupinate, occasionally with a very narrow tomentose, brown, reflexed margin 1–2 mm. wide, the hymenial surface dark brown, the margin usually nearly white in young specimens but finally darkening; in section 100–250$\mu$ thick, rusty brown, darker or blackish toward the substratum, homogeneous but sometimes with two layers, hymenium composed of two kinds of hyphae, one 3–4$\mu$ diameter, dark brown and more abundant in the lower part of the context where the arrangement is nearly horizontal, the other paler, 2–2.5$\mu$ diameter and comprising most of the context in the upper part; spores cylindric, curved, hyaline 5–7$\times$2$\mu$; cystidia often rather obscure but present, colorless, heavily incrusted but the incrustation dissolving in KOH, very thick-walled, 50–80$\times$15–20$\mu$, immersed or slightly projecting; brownish branched paraphysis hyphae present in the hymenial region.

On dead wood of various deciduous trees. The species is not common in Pennsylvania. It is best differentiated from *S. albobadium* by the much larger cystidia. In section, exclusive of the paraphyses, it resembles *Peniophora cinerea*. Additional specimens are at hand from Massachusetts, Connecticut, West Virginia, Tennessee and Missouri.

# The Development of the Embryo Sac and the Seed of Commelina angustifolia Michx.

R. L. McCollum

(WITH PLATES 19 AND 20)

De Jussieu (1839) studied the embryos of the Monocotyledonous plants almost a hundred years ago and has given an illustration of an isolated embryo of *Commelina tuberosa* which is very similar to those of other members of this group which have been described since that time.

Among other Monocotyledonous embryos, Solms-Laubach (1878) studied those of *Tradescantia, Tinnantia* and *Heterachtia.* In the two latter genera he found evidence which led him to conclude that their stem tips were terminal in origin, but were more or less displaced to the side of the embryo by the growth of the cotyledon. He also called attention to the structure of the megasporangium, mainly on the authority of Le Maout, Seubert and Gärtner. These investigators had observed the segregation of the endosperm and embryo in the mature seed, apparently independently. The method of this separation was not made clear.

From studies on the Monocotyledons, Sargent and Arber (1915) came to the conclusion that in the young seedlings of hypogeal Monocotyledonous plants, two members are distinguished externally—the cotyledon and the main descending axis. The plumlar bud is concealed within the expanded base of the cotyledon. This expanded base constitutes a sheath protecting the plumule during germination. The apex of the hypogeal cotyledon becomes the sucker, absorbing food from the endosperm. The sucker and the sheath are usually connected by a stalk or "limb" which in some cases may be several inches in length; in other cases it may be very short or absent. They regarded the scutellum of *Avena* as strictly comparable with the sucker of *Tigridia,* and the coleoptile as resembling such sheaths as are present in seedlings of *Tigridia, Crocus Colchicum* and *Elettaria.* In hypogeal seedlings the expanded base of the cotyledon is commonly transformed into a closed cylinder, as is the case in *Arum maculatum* L., *Veratrum nigrum* L., etc. They observed that the stalk of *Commelina coelestris* is bent downward at the point where it joins the sheath. This results sometimes in the formation of a hood over the plumule. In *Elettaria,* the sucker of the cotyledon remains in the seed and is connected with the axis by a fairly long stalk. The sheath extends partly above the insertion of the stalk and partly below it. As the stalk extends to the place of its insertion on the sheath, it lies parallel to it.

Quite recently Miss Boyd (1932) has studied seedlings of *Tinantia fugax*, *Commelina coelestris*, *C. dianthifolia*, *C. graminifolia*, and *Tradescantia geniculata* in some detail and other members of the Commelinaceae less exhaustively, and finds a marked uniformity in the structure of the embryos and their mode of germination. The author finds that *Commelina angustifolia* is very similar to these species in structure and germination.

Suessenguth (1921) has studied the development of the embryo in the Angiosperms, paying special attention to the early development of the stem tip and the cotyledon. Among the Commelinaceae *Tradescantia myrtifolia* was studied. He is of the opinion that the terms "lateral" and "terminal," in reference to the growing points of embryos, should be abandoned and, in their places, we should recognize *either*, those embryos whose original terminal cells form only the cotyledon, while the plumule is formed from lower lying cells (the *Alisma* type); or those embryos whose original terminal cells give rise to the cotyledon wall and the plumula. *Tradescantia*, *Tacca* and apparently also *Potamogeton*, *Ruppia*, *Zannichellia* and *Naias* are given as examples of this latter group.

Concerning the development of the gametophyte in the group, Guignard (1882) reported the megaspore mother cell of *Commelina stricta* as sub-epidermal. It divides unequally to give a micropylar cell about one-third the size of the inner cell. The outer of the two cells becomes crushed as the chalazal cell enlarges. He regarded the embryo sac as having arisen from this inner cell of the first division of the mother cell. No evidence is presented to support the conclusion that the embryo sac mother cell is sub-epidermal. Although he reports *C. stricta* to be without a parietal cell, from his figures it seems quite probable that he saw the division of the archesporial cell to form the parietal cell and the mother cell and not the first division of the mother cell.

In *Commelinantia Pringlei* (S. Wats.) B. C. Tharp, Parks (1935) was not able to distinguish the spore mother cell from the other nucellar cells until the prophases of the heterotypic division. At this stage a some-

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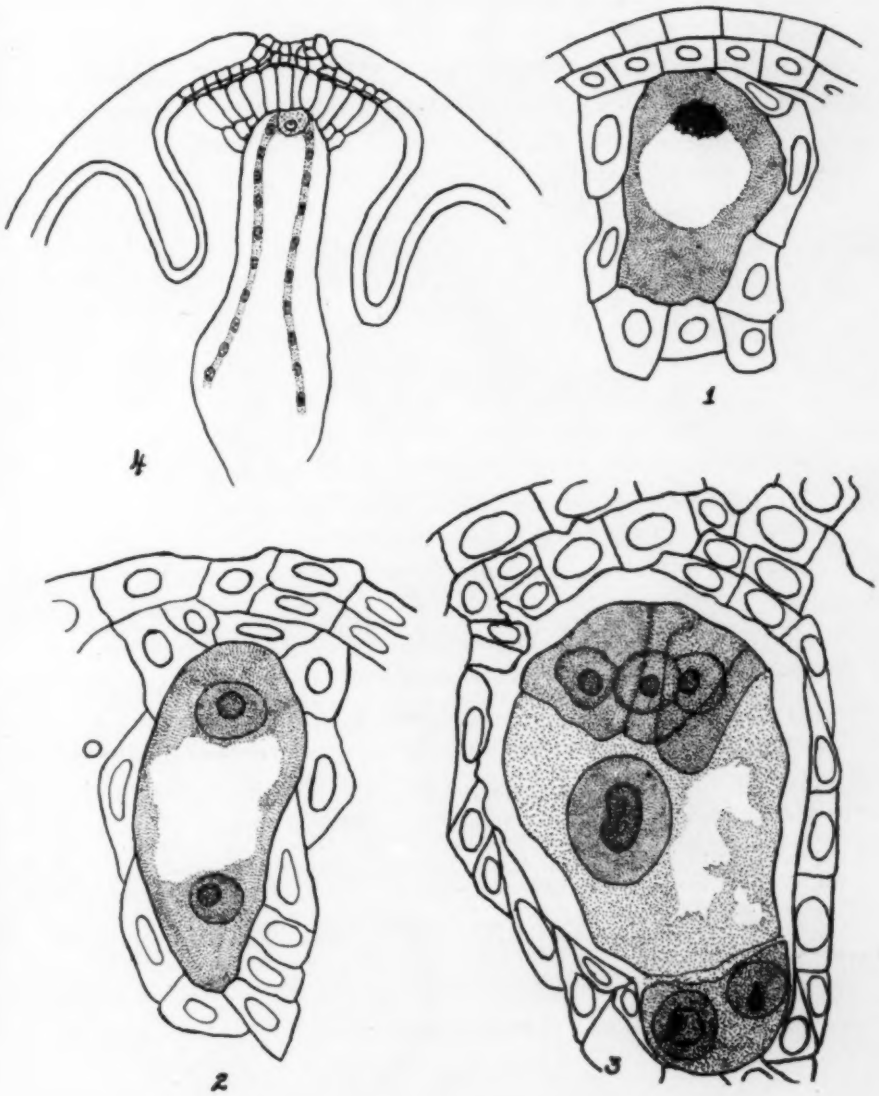
**Explanation of Figures**

The figures of plate 19 and figure 9 of plate 20 were drawn with the aid of a camera lucida.

**Explanation of Plate 19**

Fig. 1. Megaspore mother cell in synapsis. ×1300.
Fig. 2. Two-nucleate stage of the mother cell. ×1300.
Fig. 3. Mature 8-nucleate embryo sac; polar nuclei fused. ×1300.
Fig. 4. Fertilized egg stage; endosperm has partly digested the nucellar tissue and has already deeply invaded the chalazal area. ×127.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what flattened cell lies between the megaspore mother cell and the epidermis. After the second division of the mother cell the three outer cells degenerate and the large inner cell divides twice to form a four-nucleate embryo sac.

*Commelina angustifolia* Michx. grows abundantly in the Austin region. It is found in gardens and waste places throughout the summer. Some stages were obtained also from greenhouse material during the winter.

Strong chrom-acetic fixative and Nawaschin's fluid were used in fixation, the latter being possibly the most satisfactory. The usual technique was followed in embedding in paraffin. Delafield's and Heidenhain's haematoxylin stains were used with equal success. Ripe seeds were embedded in celloidin and sectioned with the aid of a hand microtome at thicknesses of from 30 to 40 microns. Young seedlings with the sucker still surrounded by the endosperm were also embedded in celloidin while others were dissected out of the endosperm before embedding.

The megaspore mother cell is difficult to recognize until it enters into the prophases of the first reduction division. During synapsis it is easily recognized by its large size and the conspicuous cell contents (Pl. 19, fig. 1). A definite layer of cells lies between the epidermis and the other cell,

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**Explanation of Plate 20**

Fig. 1. Surface view of rounded side of seed. ×7.5.

Fig. 2. An edge of seed showing raphe on upper side and lid on right end. ×7.5.

Fig. 3. End of seed, showing the lid pushed to one side in early germination. ×15.

Fig. 4. Hypocotyl projecting from the seed; raphe shown as elongated line on front surface. ×7.5.

Fig. 5. Tip of hypocotyl turning down in response to gravity; disc-like collar above primary root. ×7.5.

Fig. 6. A somewhat later stage than that in fig. 5. ×7.5.

Fig. 7. A later stage showing four secondary roots coming from the disc. ×7.5.

Fig. 8. The roots are well anchored in the soil at this stage; the upward growth of the limb and sheath has begun. ×7.5.

Fig. 9. An immature embryo lying near the micropyle; section cut at one side of the micropyle. ×42.

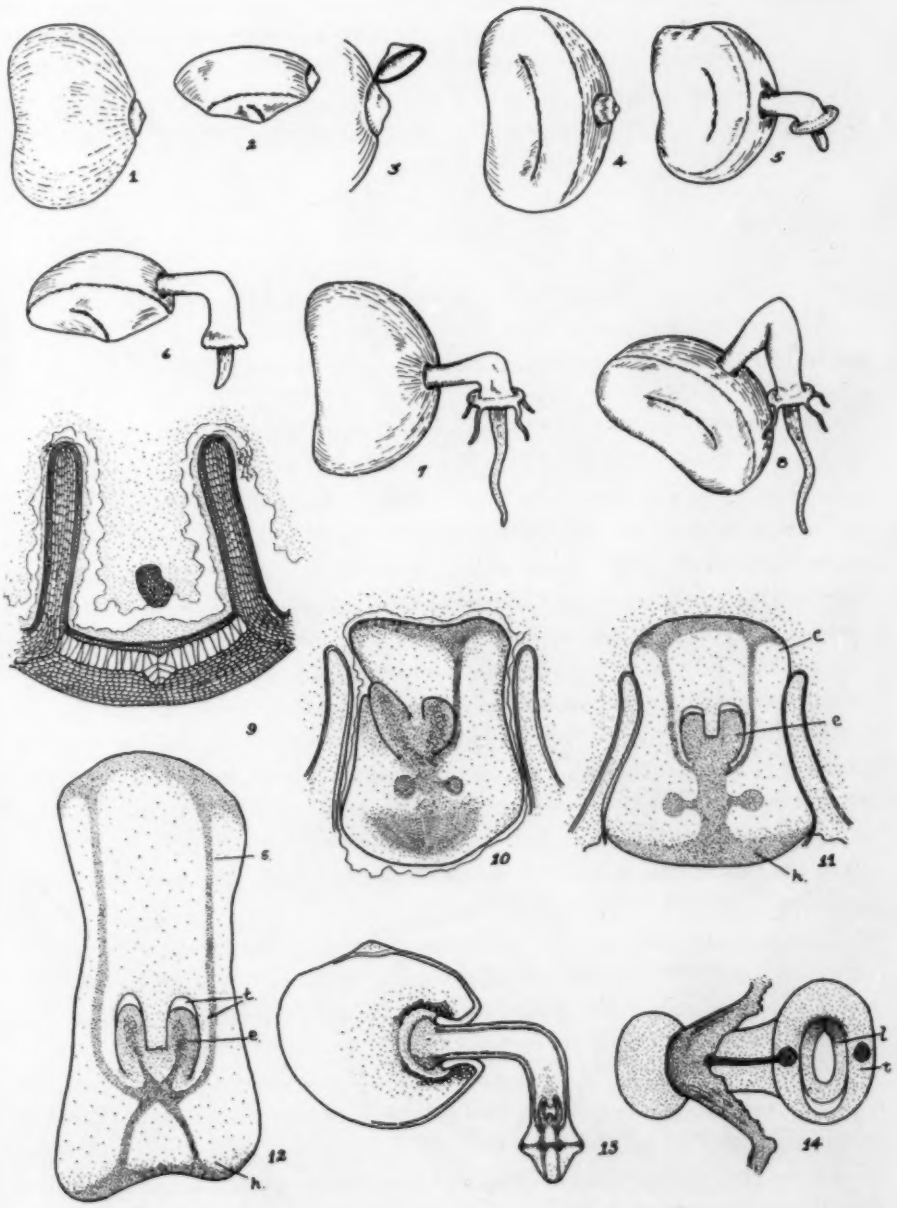
Fig. 10. Embryo nearly mature; cotyledonary tube not fully closed; longitudinal section. ×42.

Fig. 11. Longitudinal section of mature embryo; h. hypocotyl, e. epicotyl, c. cotyledon. ×42.

Fig. 12. A germinating embryo; dissected from the seed; h. hypocotyl, e. epicotyl, t. cotyledonary tube, s. sucker; limb not yet distinct from sucker; longitudinal section. ×42.

Fig. 13. Longitudinal section of seedling and seed; the sucker embedded in the endosperm; apical bud now visible within the cylinder formed by the first leaf. ×11.

Fig. 14. A seedling about the age of that of fig. 7; the section cut parallel to the limb and at right angles to the tube and above the apical bud; the tube is of unequal thickness and encloses the rolled first leaf l. ×20.




McCOLLUM: COMMELINA

and the cell occupying the position of the parietal cell differs little from the others in the layer.

It seems quite certain that all four of the nuclei resulting from the meiotic divisions of the megaspore mother cell, enter into the structure of the embryo sac. The lack of any evidence of walls separating the nuclei, also the lack of any evidence of the disintegration of any of these nuclei, points definitely to the same conclusion.

No stages were observed such as have been reported by Bambacioni (1928), Cooper (1935) and others for certain members of the Liliales in which the three innermost of these four megaspore nuclei undergo fusion after reaching early anaphase, the single mass of chromosomes immediately separating into two masses of chromosomes which then enter into the interphase stage, along with the two nuclei formed normally from the micropylar nucleus.

The development of the megasporangium of *C. angustifolia* is similar to that of *Commelinantia Pringlei* (Parks, 1935). Shortly after the maturity of the embryo sac a constriction is formed immediately back of the antipodal area of the sac by an ingrowing collar-like ring from the outer integument (Pl. 19, fig. 4). This restricts the development of that part of the sporangium adjacent to the micropyle so that very little further growth occurs here. In the subsequent development the growth on the chalazal side of the constriction is very rapid. Fertilization stimulates this growth greatly and it continues to the maturity of the seed. Part of the resulting tissue even surrounds the micropylar part of the sporangium and covers it except at the tips of the integuments at the micropyle. This conspicuous growth is perpendicular to the main axis of the campylotropous ovule and results in a flattened seed convex on one side and nearly plane on the other. A similar development has been described for *Commelinantia Pringlei* (Parks, 1935).

The early development of the endosperm is of the familiar "nuclear" type and naturally is first seen on the micropylar side of the constriction. Later it extends into the tissue on the chalazal side of the constriction which has by this time become many times greater than that of the micropylar part (Pl. 19, fig. 4). The endosperm develops rapidly and finally replaces all the internal parenchymatous tissue of the micropylar side and nearly all that on the chalazal side of the constriction.

In its early phases the young embryo is seen close to the micropyle and partly surrounded by the emdosperm. Somewhat later the embryo shows an asymmetry which is probably due to the early lateral differentiation of the cotyledon (Pl. 20, fig. 9), similar to corresponding stages

figured by Solms-Laubach (1878) for *Heterachtia*. The author has been unable to secure satisfactory views of the growing point of the young embryo and can not say with certainty whether the origin of the cotyledon is the same in *Commelina* as described for *Heterachtia*. When recognizable the epicotyl occupies a central position and remains so to maturity.

As the embryo nears maturity the epicotyl may be seen to have differentiated into the first leaf which surrounds an apical meristem (Pl. 20, fig. 11). The cotyledon has grown upward and surrounds the epicotyl. Occasionally one sees one side of the leaf extended out into the yet unclosed opening through the base of the cotyledon (Pl. 20, fig. 10). However, at maturity this opening is so completely closed that it is difficult to locate its original position. At maturity the stem tip is in the center of an enclosed tube of cotyledonary tissue. (Pl. 20, fig. 11).

As the embryo matures it absorbs the endosperm adjacent to it in the micropylar cavity and completely fills this cavity (Pl. 20, fig. 11). Its upper end, the sucker, extends out into the chalazal area of the sporangium and enlarges to form a slight knob. In the ripe seed the embryo appears remotely dumb-bell shaped, being slightly lobed on each end with a constriction between.

In the dormant condition of the embryo the hypocotyl rests against a disc of tissue formed from the micropylar parts of the integuments. Figure 9 of Pl. 20 shows this disc partly developed. The drawing is from a section cut to one side of the micropyle so that the integuments seem to be covered with the surrounding tissue which is in the background. When the seed is soaked previous to germination the disc is easily displaced by the pressure of the swelling embryo (Pl. 20, fig. 3).

Solms-Laubach (1876) refers to the occurrence of such a disc in *Tinantia, Heterachtia* and other members of the *Commelinaceae*. Hutchinson (1934) mentions it as a "disc-like callosity" of the seeds of the family and calls attention to the use earlier of the terms "embryotega or embryostega" to characterize it (Clark, 1881). Miss Boyd uses the term "lid" in reference to these structures in *Tinantia fugax* (1932).

Two vascular bundles supply the embryo root, two the first leaf of the epicotyl and two the cotyledon. These seem to converge at a region immediately below the epicotyl. At the base of this convergence four bundles branch off which later supply the four lateral roots of the young seedling (Pl. 20, figs. 10, 11 and 12).

The seed is noticeably flattened and is convex on one side and practically flat on the other, which is the side attached to the placenta. This surface shows a long, slightly curved ridge or raphe (Pl. 20, figs. 2 and 4).

The embryo lies at an angle of 90° to the long axis of this ridge. The convex side of the curve of this ridge is toward the position of the embryo (Pl. 20, figs. 4 and 8). The micropyle and "lid" thus appear on the edge of the flattened seed.

In the early stages of germination the cotyledonary region of the embryo elongates and pushes the basal part of the embryo out of the seed coat (Pl. 20, fig. 4). After the hypocotyl has grown out for a short distance beyond the seed, the tip becomes sensitive to gravity and turns down (Pl. 20, fig. 13). A disc-like collar soon forms, apparently at the juncture of the stem and root (Pl. 20, figs. 5, 6, 13). Rapid growth of the tap root follows and four lateral roots form equidistantly on the disc (Pl. 20, figs. 7,8). The seedling, at this stage, when covered with soil is anchored at the one extremity by the "seed" and at the other extremity by the tap and lateral roots. By this time those parts of the embryo between the "seed" and the root disc have already begun to elongate upward (Pl. 20, figs. 7, 8). The parts concerned in this elongation are the cotyledonary limb on the side connected with the seed and the cotyledonary sheath surrounding the epicotyl on the other side (Pl. 20, fig. 8). These must of necessity grow alongside until the plumule breaks out of the sheath at the surface of the ground.

At the base of the sheath, within the cylinder of the first foliage leaf, there is a bud which develops to form the next internode and the second foliage leaf. The meristem at the base of this second leaf repeats this development so that, in a seedling shortly before it appears above the ground there may be several leaves separated by internodes, telescoped one within the other.

The separation of the seed into two distinct regions or compartments, the one containing the embryo and the other the endosperm, seems to have been observed only in the Commelinaceae. At first thought, the early separation from the endosperm may appear to be an adaptation to insure the carrying over of abundant endosperm. However the embryos of the Commelinaceae are often as large as those of many seeds in which the embryo is surrounded with endosperm as *Asparagus*, *Smilacina* and other members of the Liliaceae. From these examples it would seem that in the Monocotyledons, embryo size has little relation to its proximity to the endosperm.

Cotyledonary "limbs" which are attached to the top of the cotyledonary tube are not peculiar to the Commelinaceae, but are found in various genera of the Liliaceae. If the seeds of such plants are buried deeply the delicate limb becomes unduly extended upon germination and

must be very susceptible to injury when in this condition. The organic nutrients from the endosperm must pass twice as far to reach the developing root, the hypocotyl and epicotyl as would be the case if the limb was attached to the base of the tube. It is probable that very few seeds of these genera in question are too deeply buried but more often are not buried deep enough so that the normal limb would be very short.

In *Galtonia*, the Alliums, and others of the Liliaceae, the cotyledonary limb normally grows vertically downward, carrying the radicle and plumule deeply into the soil, producing a situation similar to that found in *Commelina* in which the organic food must be transported a considerable distance through a very slender structure. These limbs and their downward growth are very suggestive of the slender "droppers" of the Tulip by means of which the terminal bud is carried deeper into the soil each season. The "dropper" is a slender tubular structure carrying the terminal bud in its tip. Most of the remaining organic food of the last bulblet is transferred to the new bulblet through the vascular system of the dropper. These droppers are scarcely larger than the limbs of Commelinaceae but may be very long, exceeding nine inches (Arber, 1925). Such delicate structures, distinctly different in their origin, thus are frequently used among the Monocotyledons to protect the stem bud and to supply nutrition when it is being brought to the surface or carried deeper into the soil.

University of Texas
Department of Botany and Bacteriology
Austin, Texas

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# The Cytology of Apogamy in Pteris cretica Linn. var. albo-lineata Hort.

ALPHONSE L. HEUN

(WITH PLATES 21 AND 22)

The first evidence of apogamy in a ferm was reported by Lesczyc-Suminski (1848) who observed tracheids in the prothallium of *Pteris sulcata*. Later Wiegand (1849) in some mixed fern cultures found prothallia which produced at the apical notch conical processes bearing embryos, which were, no doubt, of apogamous origin. Mercklin (1850) also found tracheids in the prothallium of *Pteris sulcata* and figured a gametophyte of a fern, probably that of *Notholaena Eckloniana*, with a sporophyte of apogamous origin.

Farlow (1874) clearly described for the first time the phenomenon of apogamy in a fern, in *Pteris cretica* var. *albo-lineata*, in which he observed that the apogamous embryo is an asexual growth from the ordinary prothallial cells. The first evidence of the apogamous embryo, according to Farlow, was the appearance of a pale green region in the gametophyte immediately back of the apical notch, in which tracheids later on developed. Frequently there was formed a process similar to that described by Wiegand (1849) from which an embryo was often observed to develop, usually on the ventral side of the prothallium just posterior to the process. The leaf of the embryo appeared first, then the root and finally the stem. The foot was always absent. De Bary (1878) also investigated the origin of the embryo of *Pteris cretica* var. *albo-lineata* and found it to be constantly apogamous.

Since the investigations of Farlow (1874) and De Bary (1878) apogamy has been discovered in numerous ferns and has been studied by many botanists including: Hayes (1924), Heilbronn (1910), Heim (1896), Kny (1895), Lang (1898, 1924, 1929), Leitgeb (1886), Nagai (1914), Pickett and Manuel (1925), Sadebeck (1879), Stange (1887), Sarbadhikari (1939), Steil (1911, 1915, 1918, 1919, 1933), Woronin 1907, 1908) and Yamanouchi (1908b).

Only a few cases of apogamy have been cytologically investigated. Farmer, Moore and Digby (1903) reported that in the gametophyte of *Lastraea* (*Dryopteris*) *pseudo-mas* var. *polydactyla* (Wills) and in *Lastraea* (*Dryopteris*) *pseudo-mas* var. *polydactyla* (Dadds) there occurred first a fusion of two vegetative cells and their nuclei. According to their description, the diploid apogamous sporophyte originated from the

cell resulting from these fusions. Binucleated cells have been reported in the prothallia of other ferns by Lang (1898) and Hayes (1924), but these cells never produced apogamous sporophytes. Miss Hayes also found "fusion" nuclei in the gametophyte of *Pellaea atropurpurea*. Stephens and Sykes (1910) described binucleate cells in the gametophyte of *Pteris droogmantiana*. They showed, however, that this nuclear condition resulted from a mitotic division which was not followed by cell division.

Miss Digby (1905) found that in *Nephrodium* (*Dryopteris*) *pseudo-mas* Rich. var. *cristata* there occurred no reduction division. The diploid number of chromosomes was found in both the gametophyte and the sporophyte generation. Farmer and Digby (1907) studied the chromosome number in some apogamous and parthenogenetic ferns. Also, in 1907 they reported a haploid sporophyte in the apogamous *Lastraea* (*Dryopteris*) *pseudo-mas* var. *cristata apospora*. The chromosome numbers in apogamous ferns which have been cytologically investigated are as follows:

| | *Gametophyte* | *Sporophyte* | *Haploid or Diploid* | *Worker* |
|---|---|---|---|---|
| *Athyrium filix-foemina* var. *clarissima* Jones .. | 90 | 90 | Diploid | Farmer, Digby (1907) |
| *Nephrodium* (*Dryopteris*) *pseudo-mas* var. *cristata* | 50 | 50 | Diploid | Farmer, Digby (1907) |
| *Lastraea* (*Dryopteris*) *pseudo-mas* var. *cristata apospora* ..... | 60–78 | 60–78 | Haploid | Farmer, Digby (1907) |
| *Lastraea* (*Dryopteris*) *pseudo-mas* var. *polydactyla* Wills. ..... | 64–66 | 128–132 | ..... | Farmer, Digby (1907) |
| *Lastraea* (*Dryopteris*) *pseudo-mas* var. *polydactyla* Dadds ..... | 64–66 | 128–132 | ..... | Farmer, Digby (1907) |
| *Nephrodium* (*Dryopteris*) *molle* ..... | 64–66 | 64–66 | Haploid | Yamanouchi (1908) |
| *Nephrodium* (*Dryopteris*) *hirtipes* ..... | 60–66 | 60–66 | Haploid | Steil (1919) |
| *Aspidium* (*Dryopteris*) *remotum* ..... | 130 | 130 | Haploid | Döpp (1932) |
| *Aspidium* (*Dryopteris*) *filix-mas* var. *cristata*.. | 80 | 80 | Haploid | Döpp (1933) |
| *Aspidium* (*Cyrtomium*) *falcatum* ..... | 60–66 | 60–66 | Haploid | Allen (1911) |
| *Marsilia Drummondi* .... | 16 or 32 | 32 | ..... | Strasburger (1907) |
| *Pellaea atropurpurea* ... | 40 | 40 | Haploid | Hayes (1924) |

Similar fusions of cells were described by Miss Allen (1911) in *Aspidium* (*Cyrtomium*) *falcatum*. According to her description the hap-

loid sporophyte arises from a haploid gametophyte. In the sporangium sixteen sporocytes fuse in pairs and produce eight diploid spore mother cells which produce, in the ordinary way, thirty-two haploid spores. Strasburger (1907) found two kinds of mother cells in the macrosporange of the heterosporous *Marsilia Drummondi*. Some macrospore mother cells of this fern contain larger nuclei than others. The smaller nuclei pass through a typical reduction division to form the normal spores. The larger nuclei, however, Strasburger describes as passing through an apparent synapsis which is followed by no reduction of the chromosome number. Yamanouchi (1908 b) found in *Nephrodium* (*Dryopteris*) *molle* that the prothallia bore both antheridia and archegonia, and that under ordinary conditions fertilization took place, but, if the prothallia were watered only from below and grown in strong light, apogamous sporophytes were produced. Yamanouchi observed no migrations of nuclei as described by Farmer and Digby (1903), but that the haploid sporophyte arose directly from the gametophyte. Miss Black (1909) and Mottier (1915) attempted to produce apogamous embryos in *Nephrodium* (*Dryopteris*) *molle* but failed to obtain them, although as far as possible they used the same culture methods employed by Yamanouchi. Mottier questions the apogamous origin of the embryos described. Steil (1918) also made futile attempts to obtain under cultural conditions similar to those described by Yamanouchi, apogamous embryos of *Osmunda regalis*.

Steil (1919) found in *Nephrodium* (*Dryopteris*) *hirtipes* that a haploid sporophyte arises from the vegetative cells of the haploid gametophyte. When eight sporogenous cells have been produced, they undergo incomplete nuclear and cell divisions, which result in the production of eight spore mother cells with the diploid number of chromosomes. The diploid spore mother cells thus produced undergo the reduction divisions and produce thirty-two haploid spores. Steil (1919) found that similar incomplete ("interrupted") divisions occur in the spore sacs of *Aspidium* (*Cyrtomium*) *falcatum*. Döpp (1932) also found in the spore sacs of the apogamous *Aspidium* (*Dryopteris*) *remotum* incomplete nuclear and cell division similar to those described by Steil. Döpp (1933) also described the same phenomenon in much detail in the apogamous *Aspidium* (*Dryopteris*) *filix-mas* var. *crist*. Hort.

Miss Hayes (1924) investigated the cytology of *Pellaea atropurpurea* and although she found binucleated cells, migrating and apparently "fusion" nuclei she could not trace the origin of the apogamous embryo to fusions of ordinary gametophyte cells. Miss Hayes found forty chromosomes in both gametophyte and sporophyte. Since no fusions or incom-

plete nuclear divisions occurred in the sporogenous cells the reduction divisions failed to take place.

## MATERIALS AND METHODS

The spores for cultures were collected in the Marquette University greenhouse and in the Mitchell Park Conservatory at Milwaukee, Wisconsin. The prothallia were grown in Erlenmeyer flasks containing Beyerink's solution as modified by Moore. The cultures were kept in a Wardian case in the greenhouse. Protonema-like filaments were formed in cultures in which the spores were sown very thickly. These filamentous prothallia bore antheridia only. In the cultures exposed to good light normal prothallia developed. The material for cytological study was fixed in Flemming's medium strength fluid or in a modified Navashin's solution. Preparations were stained with the Flemming triple: safranin, gential violet and orange G, and with Heidenhein's iron hematoxylin. Safranin and fast green proved very satisfactory for the counting of the chromosomes. The sections were generally cut 10 microns in thickness. Spore mother cells were counted in serial sections. Spore counts were made both from prepared slides and by removing a mature spore case and placing it into a drop of water on a slide. A cover glass was then placed on the mount and a drop of glycerin was introduced. The counts could then be readily made.

## OBSERVATIONS

### *The Gametophyte*

The prothallia of *Pteris cretica* var. *albo-lineata*, when exposed to good light, broaden out and form typical heart-shaped structures. These

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**Explanation of Plates**

All figures were drawn with the aid of a camera lucida. All except 6 and 16 were drawn at 2650 diameters. Figures 6 and 16 were drawn at 1620 diameters. The figures in Plate 21 have been reduced about one-sixth and those in Plate 22 have been reduced to one-half in the printing reproduction.

**Explanation of Plate 21**

Fig. 1. A polar view of a vegetative cell of the gametophyte showing the 32 chromosomes.

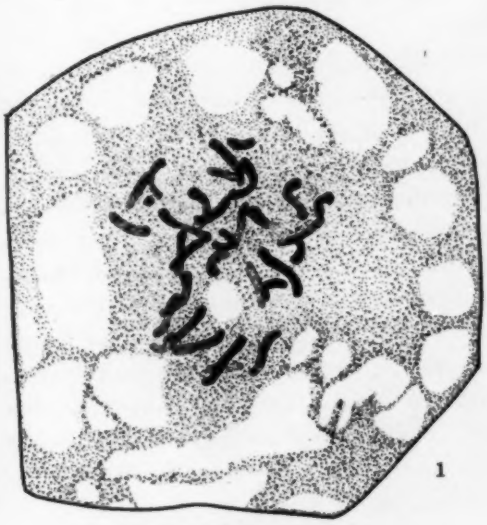
Fig. 2. Longitudinal section through a metaphase of a vegetative gametophyte cell.

Fig. 3. Metaphase of a young sporophyte cell. All of the chromosomes are shown.

Fig. 4. Polar view of a root tip cell in metaphase. There are 32 split chromosomes.

Fig. 5. Metaphase in a cell of a very young sporangium showing the full chromatin content.

Fig. 6. Four of the eight spore mother cells with disintegrating tapetum surrounding them.



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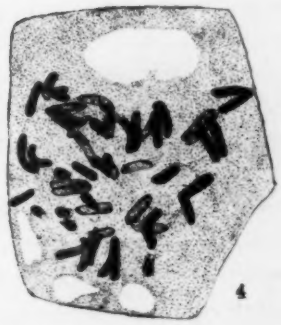

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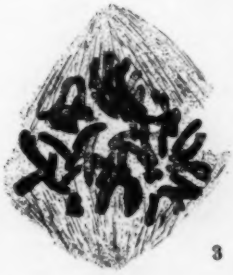

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bear rhizoids, antheridia and archegonia. In the cultures practically all of the normally developed prothallia produce archegonia, but the latter are few in number, varying from one to four on each gametophyte. They develop in the normal way producing a definite neck and venter in which an egg is formed. However, the entire contents of the archegone including the egg cell disintegrates.

Mitotic figures were observed in the young antheridia and in the vegetative cells of the prothallia. In polar view during anaphase (fig. 1, Pl. 21) the chromosomes are more or less scattered and the count is readily made. The chromosome number in the nucleus, represented in the figure, as well as in all others in which counts were made, was found to be 32. Figure 2, Pl. 21, shows a longitudinal section through a vegetative cell of the gametophyte. About two-thirds of the chromosomes are represented. This figure shows the broad spindle poles and the chromosomes in the equatorial plate stage. The number, 32, is believed by the writer to be the haploid number which is about half of the number reported in the gametophyte of the common *Dryopteris* species of ferns.

### *The Sporophyte*

The apogamous development of the sporophyte of *Pteris cretica* var. *albo-lineata*, as has been stated, was investigated by Farlow (1874) and De Bary (1878). The author has confirmed, as a result of his studies, the conclusions of these workers.

In the cells of the young apogamous sporophyte the writer counted the chromosomes and the haploid number of 32 was found to be present. In the sporophyte the division figures are comparatively abundant. Figure

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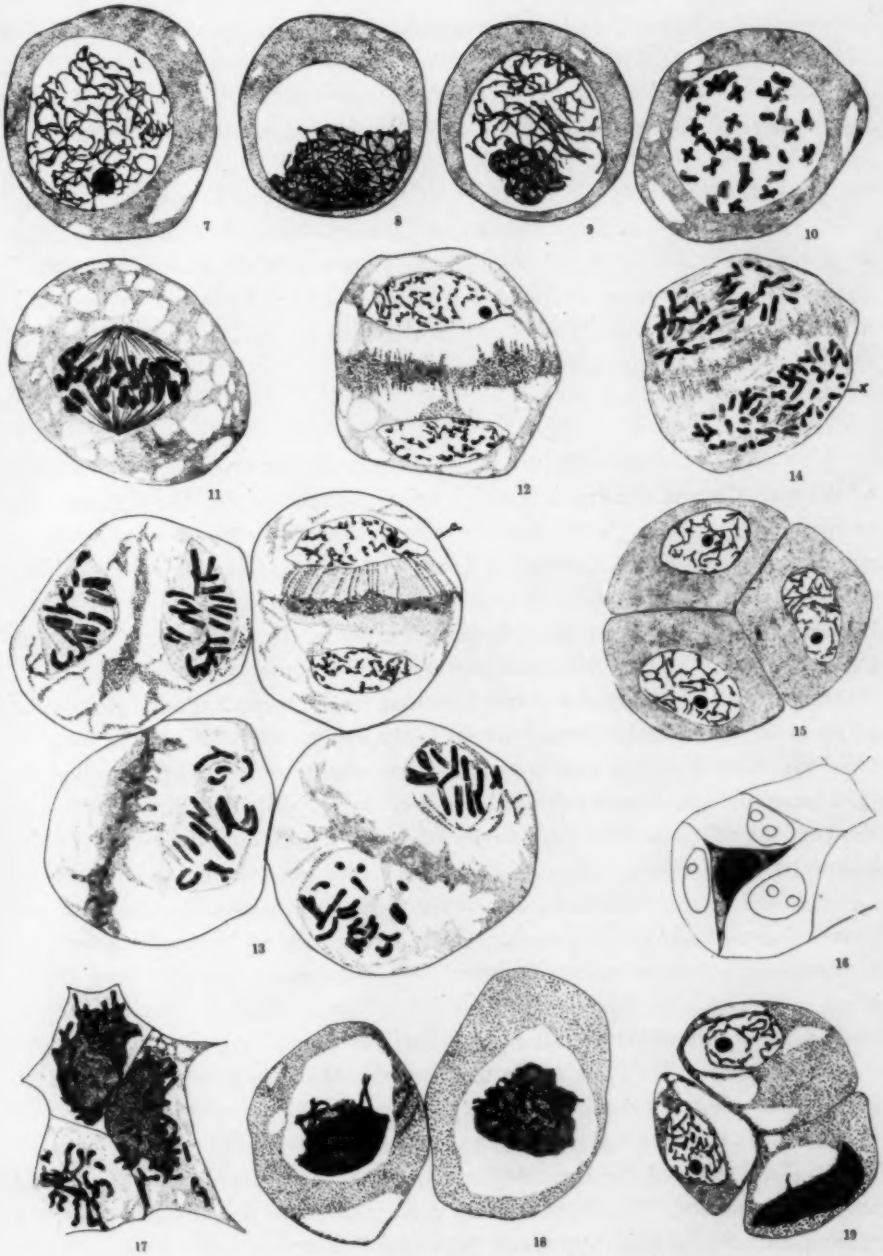
**Explanation of Plate 22**

Fig. 7. Early prophase in a spore mother cell.
Fig. 8. Pseudo-synapsis in a spore mother cell.
Fig. 9. Leptonema stage showing the longitudinal split of the spireme.
Fig. 10. Diakinesis in a spore mother cell. Thirty-two split chromosomes are shown. This is the entire complement of the cell.
Fig. 11. The first metaphase in a spore mother cell. All of the chromosomes are shown.
Fig. 12. Interphase between the two divisions preceding spore formation. A nucleolus is present in one nucleus.
Fig. 13. A group of spore mother cells, one of which is in interphase, the others in the second metaphase.
Fig. 14. Second anaphase in the spore mother cell, showing at X the 32 chromosomes.
Fig. 15. A tetrad of young normal spores.
Fig. 16. Abortion in the archesporial cell.
Fig. 17. Abortion in sporogenous tissue.
Fig. 18. Abortion in the spore mother cells occurring during synapsis.
Fig. 19. Abortion in young spores.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3, Pl. 21 shows a metaphase stage in the young sporophyte. The chromosomes can be distinguished readily although, on account of the smaller size of the young sporophyte cells, a more compact arrangement of the chromosomes results and hence they are more difficult to count. In this figure there is shown the complete chromatin complement, consisting of 32 split chromosomes.

The meristematic region of the root tip was studied in longitudinal and transverse sections, and the number of chromosomes counted. A polar view of the metaphase (fig. 4, Pl. 21) of the root tip of a mature sporophyte shows the chromosomes well distributed over a broad plate which extends almost to the cell wall. There are in the nucleus of the root tip cell 32 chromosomes, as represented in the figure.

### *The Sporangium*

The cells of the sporangium in their early stages are larger than those of the root tip and the crozier, which were also studied for the chromosome number. Figure 5 of Pl. 21 shows a cell of a developing sporangium. This cell is only one division removed from the sporangium initial cell. This cell shows 32 chromosomes as represented in the figure. Hence, there has been no change in the number of chromosomes in the life cycle of the fern, the sporophyte having the same number as the gametophyte.

As a result of the study of the tapetum of the spore sac, disintegration of its cells was found to occur at an early stage, the walls of the tapetal cells are first digested and then the tapetal nuclei disintegrate. By the time the eight spore mother cells have been developed, the disintegration of the tapetal cells has been completed (fig. 6, Pl. 21) and their nuclei have begun to break down. The eight spore mother cells shown in this figure are rounded on the sides adjacent to the periphery of the sporangium, and have attained their maximum size. Their cytoplasm is dense and granular. The nucleus is located centrally, is of large size, spherical and deep staining. The chromatin forms a net-like structure, which in no instance is composed of a double thread. Hence, there is no pairing of chromosomes.

In the prophase of the spore mother cells there appears to be, at first glance, a typical sequence of the stages of a meiotic prophase. Figure 7 of Pl. 22 shows such an early stage of the prophase. There has occurred no longitudinal split of the threads the number of which, at this stage, could not be determined. The chromosomes next pass into what appears to be a synaptic knot. In this apparent "synapsis" there is not at any time a pairing of the chromosomes (fig. 8, Pl. 22). Hence, a true synapsis does not take place. The longitudinal split of the threads occurs at the end of

this pseudo-synapsis, and the knot loosens up in a typical leptonema-like stage (fig. 9, Pl. 22). In this stage the threads are thin but show evidence of a longitudinal split. There now occurs a contraction of the chromosomes. There is no tetrad formation at any time in the mitotic divisions. The chromosome pairs are well distributed throughout the nucleus, which has regained its central position within the cell. The cytoplasm of the spore mother cell, at this stage, is more highly vacuolate than in the earlier stages. The chromosomes were counted at this stage in a number of cells and found to be 32 in number. Figure 10 of Pl. 22 shows all of the chromosomes of an apparent "diakinesis." The chromosomes next arrange themselves in pairs upon a rather narrow plate in the center of the mother cell (fig. 11, Pl. 22). The well developed spindle fibers appear to be in groups as shown in the figure. The chromosomes are drawn to the poles by the spindle fibers, all of the split chromosomes being separated and reaching the poles. Evidently a mitotic division of the nucleus has occurred instead of a meiotic division.

At this stage in the development of the spore there ensues a typical interphase (figs. 12 and 13a, Pl. 22), the chromatin passing into the metabolic condition during which time there is produced a nuclear membrane. A second spindle is later formed. Up to this time there has been a complete uniformity in the development of the sporogenous tissue within a single sporangium, although within a sorus one may find various stages of development from sporangium initial cells to sporangia containing mature spores. The individual chromosomes which are longitudinally split can be readily observed in metaphase. The cells represented in figure 13, Pl. 22 show this split condition of the chromosomes. Only a few chromosomes are represented in these cells, the remainder appearing in the adjacent sections of the series. The chromosomes are slightly thinner than those of the previous division but retain their characteristic length and shape. The spindle fibers separate the split halves of the chromosomes and draw them to opposite poles (fig. 14, Pl. 22). Chromosome counts were again made in each of the two dividing nuclei of the spore mother cell, and 32 chromosomes were found to be present.

Spindle fibers are in evidence after the second mitotic division has been completed (fig. 14, Pl. 22). The walls of the spores, at first thin, become quite thick. The four members of the tetrad of spores are not separated at once, and it seems that the secondary thickenings, resulting in the highly sculptured condition of the mature spores, is partially responsible for their separation. The cytoplasm in the young spores is again very dense and not highly vacuolate (fig. 15, Pl. 22), and the nucleus is ap-

proximately in the center of the cell. A nuclear membrane is present and the chromatin appears to form a reticulum. One or more nucleoli have appeared in each nucleus.

### *Abortion in the Sporangium*

Only about 30 per cent of the sporogenous cells of *Pteris cretica* var. *albo-lineata* develop normal spores. The remainder disintegrate at various stages in the development of the sporangium. The earliest evidence of abortion of sporogenous tissue observed by the writer occurred when the primary cell has been differentiated (fig. 16, Pl. 22). The nucleus in the aborted cell stains deeply, and is often an apparently homogeneous mass. In most instances in such disintegrating cells, there are present in the cytoplasm extrusions of chromatin. Several masses of "chromatin" are sometimes visible in the cytoplasm as shown in figure 16 of Pl. 22. Figure 17 of Pl. 22 shows abortion occurring at the four celled stage. It appears ordinarily, as shown in this instance, that disintegration occurs during the time of nuclear division. In the spore mother cells no disintegration was observed during the resting stage of the nucleus. During pseudo-synapsis, disintegration of the nucleus commonly takes place (fig. 18, Pl. 22). In the apparent synaptic stage, the chromatin is reduced to a homogeneous mass. In one cell shown in figure 18 of Pl. 22 the remains of a few chromatin strands can be observed; in the other cell is shown a very early leptonema-like stage. The cytoplasm of the aborted cells at this stage is not of a uniform density throughout, as in the normal mother cells at "synapsis." The nucleus is irregular in outline and frequently its membrane is disappearing, or has completely disappeared. The cell seems to lack turgidity, and is apparently abnormal.

Abortion was also observed in late stages of the spore development, as shown in figure 19, Pl. 22. In this figure a tetrad of spores is undergoing disintegration. The nucleus of one of the spores in the tetrad has been reduced almost to a homogeneous mass. The only remaining distinguishable portion of the nucleus is the nucleolus. The cells are approximately the size of a normal young spore, but they no longer have their characteristic outline. There has appeared a very large vacuole near the nucleus. This large vacuole is also present in another cell of the tetrad, in which the nucleus still retains its reticulum but is irregular in form. This cell represents an earlier stage of disintegration of the spore. In the third cell of the tetrad the nuclear contents are no longer distributed evenly throughout the nucleus. The karyolymph is slightly stained. A shrinking of the nuclear material from the nuclear membrane was frequently ob-

served. Large vacuoles commonly appear in the cytoplasm of the disintegrating spore, as shown in the figure.

The cause of abortion of the sporogenous cells of *Pteris cretica* var. *albo-lineata* is unknown to the writer.

## Discussion

In the cultures of prothallia made by the writer, the normally developed gametophytes always produced antheridia and archegonia. The large heart-shaped prothallia were produced when fewer spores were sown in the culture. In this fern there are no cell and nuclear fusions like those described by Farmer and Digby (1907), or Miss Allen (1911). Neither are there incomplete nuclear and cell divisions like those described by Steil (1919) and Döpp (1932, 1933). Furthermore, since there are no reduction divisions in the life cycle, the cytology of the fern is similar to that described by Miss Hayes (1924) in *Pellaea atropurpurea*.

The chromosome number, characteristic of both gametophyte and sporophyte of *Pteris cretica* var. *albo-lineata*, as has been stated, is thirty-two. The writer assumes that this is the reduced number and therefore the sporophyte is also haploid. The haploid condition of the sporophyte in ferns has already been described by a number of workers: Farmer and Digby (1907) in *Lastraea* (*Dryopteris*) *pseudo-mas* var. *cristata apospora*, Yamanouchi (1908 a) in *Nephrodium* (*Dryopteris*) *molle*, Allen (1911) in *Aspidium* (*Cyrtomium*) *falcatum*, Steil (1919) in *Nephrodium* (*Dryopteris*) *hirtipes*, and Döpp (1932) in *Aspidium* (*Dryopteris*) *remotum* and (1933) *Aspidium* (*Dryopteris*) *filix-mas* var. *cristata* Hort. found the haploid number of chromosomes in both generations.

The writer wishes to express his appreciation to Dr. W. N. Steil of Marquette University for valuable advice and suggestions given during the preparation of this paper; to Dr. C. A. Weatherby for assistance in the nomenclature; and to Mr. C. W. Davison of the Mitchell Park Conservatory of Milwaukee, Wisconsin, for some of the *Pteris cretica* plants used in the investigation.

## Summary

The gametophyte of *Pteris cretica* var. *albo-lineata* bears both antheridia and archegonia. The antheridia develop in a normal manner, but all of the archegonia abort.

The nuclei of the gametophyte cells contain 32 chromosomes.

There is no fusion of gametophyte cells and their nuclei before the apogamous embryo begins its development.

The sporophyte is always of apogamous origin and retains the reduced chromosome number.

Eight spore mother cells are produced in each sporangium. There are no meiotic divisions preceding the formation of the spores. The mother cells contain 32 chromosomes, the haploid number. The mother cells appear to pass through synapsis but there is no pairing of chromosomes. Two divisions, which are mitotic in nature, result in the formation of 32 haploid spores.

No fusions of the sporogenous cells and no incomplete nuclear and cell divisions were observed in the spore sacs of *Pteris cretica* var. *albo-lineata*.

Since the nuclei of the sporophyte also contain 32 chromosomes, both the gametophyte and sporophyte possess the haploid number of chromosomes.

Abortion of the sporogenous tissue may occur at any time during the development, starting with the archesporial cell and extending through to the formation of the spores. Abortion of the sporogenous cells results in the disintegration of the nuclear and cytoplasmic material.

MARQUETTE UNIVERSITY
MILWAUKEE, WISCONSIN

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# A Brief History of Chinese Herbs and Medicine

LEONARD CHAN[1]

Modern Western medicine, though still occasionally hampered by tradition and custom, is largely a product of experimental research. Contrasted with this is the Chinese system of medicine which is the product of untold generations of experience and which, despite the invasion of Western ideas and customs into other phases of Chinese life, is extensively practiced today just as it was thousands of years ago. Since several ancient Chinese drugs have been adopted by American and European doctors, and since many Americans, especially in California and other Pacific Coast states, have been helped by Chinese "herb doctors," it seems of interest to briefly investigate the origin of their art.

The science and art of medicine in China go back to such remote antiquity that only legends exist to tell of the first medicinal use of herbs and other products. The study is complicated further because fact and legend are sometimes almost inextricably interwoven.

According to some of the more authentic sources, Shen Nung,[2] who lived about 2700 B.C., discovered that different kinds of vegetables and plants reacted differently in his body, and he is credited with having tested the medicinal action of some 360 varieties of plants on his own system. He found that some of these could be used to cure, or at least to allay the discomfort of certain bodily disorders. He discovered that by mixing different plants in one preparation, it was possible to accentuate or modify certain qualities of the plants. Altogether, he compounded and recorded 113 different prescriptions, some of which are used today.

Legend has it that his system was transparent and that by observing the path that herbs took when he ate them, he was able to tell the specific part of the body to which the particular herb was directed. Thus he could list a specific use for each plant. Because of the transparent system, an abnormal condition following the use of a poisonous drug was readily detected, and before the poisons could affect him he counteracted their action by drinking a concentrated extract of licorice as an antidote. This is still used among the Chinese as an antidote for many poisons.[3]

[1] The author accepts full responsibility for the authenticity of the statements in this paper, but appreciatively acknowledges the criticisms of Dr. Robertson Pratt in the preparation of the manuscript.

[2] The Chinese characters are translated in Mandarin, the official Chinese dialect.

[3] Of course, the author does not recommend this as a generally applicable antidote for poisons. It is merely mentioned as a traditional use among Chinese.

One of the most important laws set down by Shen Nung was the method of compounding prescriptions. He based the method on four characters, "emperor," "premier," "assistant," and "guide," respectively. He believed that when compounding a prescription, the proper kind of herb must be selected to act in the proper capacity according to these four characters: thus, there must be the "emperor" or the main herb which has full control of the disease concerned, the "premier" which advises the main herb as to the way it is to act, the "assistant" which will help the main herb so that it will be able to act better, and the "guide" which will prepare the way for the main herb. The philosophy of Shen Nung still lives, and this method of compounding drugs is universally employed by Chinese herb specialists.

Another important doctrine of the Chinese herbalist is the "pulse law." This too is of ancient origin. After becoming premier in the court of the emperor, Huang Ti, about 2205 B.C., Chi Pai became perturbed over the sickness and suffering of his subjects. In an effort to find means to relieve the suffering and to prevent the spread of disease he held daily conferences with the emperor to discuss methods of accomplishing these ends. The results of these conferences were recorded in nine volumes, known as Ling Shu. It is in these that first mention of the "pulse law" is found.

According to the "pulse law," all sickness may be diagnosed by feeling the pulse. In feeling the pulse, the physician uses three fingers, each of which pertains to a different organ. When feeling the patient's right hand, the speed of the pulse when felt by the second finger pertains to the lung; the third finger to the stomach and the fourth finger to the spleen. When taking the pulse from the patient's left hand, the second finger pertains to the heart, the third finger to the liver, and the fourth finger to the kidney. It is believed that the pulse felt with light pressure of the fingers pertains to the system in general, that felt with moderate pressure pertains to the internal organs, and that felt with heavy pressure pertains to the lower part of the body.

The pulse itself is based on four definitions. If it has a floating effect—i.e. feels like the touch of a piece of wood floating on water, it means that the patient is feverish; if the pulse has the effect of sinking, as if a piece of iron were to sink, it means that there is slow circulation and there is weakness throughout the whole body; if it is slow yet regular, there is merely slow circulation of the blood, and if the pulse is rapid, but regular, the blood is circulating too fast. After the diagnosis, suitable herbs are prescribed to counteract these different conditions.

Chi Pai also wrote nine volumes on the circulation of blood. These books are called Soo Wun and in them it is stated that the origin of all illness is in one or more of five parts of the body, i.e. heart, liver, stomach (including intestines and spleen), lungs and the kidneys. It is believed that since the blood circulates to these different organs, the origin of a disease may be located by merely feeling the pulse relating to the different parts of the body.

In 651 B.C., during the great wars of China, Bien Chok revised the books dealing with herbs. He selected the more useful herbs and discarded the others. His work did much to make the people believe that diseases could be cured, and even prevented, by the use of medicine. He believed that the spread of contagious diseases could be checked and plagues and epidemics prevented by the judicious use of herbs. Since surgery was still an unknown art, and theories of vaccination had not yet been developed, he had ample opportunity for "clinical" testing of his theory of "drinking medicines."

It was not until 190 A.D., during the romance of the Three Kingdoms, that a young physician, Hua To, conceived the ideas that only small quantities of medicine are needed to cure diseases and that many diseases do not originate in internal organs, but are due to external causes. He believed that certain diseases could be cured without the use of medicine. The opportunity to prove his theory came when he was called to treat Kwan Kung, a great warrior who had been struck by a poison dart. Hua To declared that only an operation would prevent death. As Kwan Kung was young, he was willing to try the new method. Of course anaesthetics were unknown, and it is stated that during the operation he diverted his mind from the ordeal by playing chess with his good arm. Thus Hua To became famous as the first surgeon. A few years later, Tsao Tsao, a prince of the Kingdom of Wei, was suffering from an infection of the brain. The most famous doctors of his country were unable to cure him, and so he sent to the Kingdom of Han for Hua To. After diagnosing the case, Hua To stated that only an operation would save the prince, whereupon Tsao Tsao became suspicious. Since he belonged to a rival kingdom, the prince thought himself the victim of a conspiracy and so he ordered the execution of Hua To. China lost her first and most famous surgeon.

Before departing from his homeland Hua To left, with his wife, written records of all his operations. After the execution, his wife, thinking the papers worthless, took them out of the house and burned them. A few papers which were not burned were later found by a passerby who, realizing their value, preserved them. It happened that these last few pages

described the castration of pigs and hens in order to fatten them before slaughter. This same method is used in China today, so his art was not lost forever.

During the Han Dynasty (206 B.C.—220 A.D.) schools were established where the use of Chinese herbs was taught. Chang Chung-ching was among the first to write text-books and he based his teachings on the works of Bien Chok. He included the 113 prescriptions of Shen Nung and compounded many new ones. Among them was the famous cinnamon Twigs Tea, which forms the basis of many herb teas used today.

The Chinese believe that poisonous substances may leave the body when the pores of the skin are opened. Thus, this tea which generally induces sweating, is used extensively. It is brewed from a mixture of cinnamon twigs; pai chao; glycyrrhiza, previously boiled with honey to bring out its flavor; ginger; and dates. When drinking the tea does not produce sweating, Ma Huang, the source of ephedrine, is added. Thus it may be seen that this tea is based on the theory of Shen Nung. Cinnamon twigs act as the "emperor" since they increase the circulation of the blood and are stimulant, thus inducing perspiration; pai chao is the "premier" and acts as an antipyretic, counteracting high temperature and presumably aiding thereby the departure of poisonous substances. Ginger is a carminative and acts as the "assistant." Dates and glycyrrhiza act as "guides," the former being a stimulant to the intestinal tract and the latter a vehicle and flavor. It should be noted that this prescription is in harmony with the belief that all sicknesses originate in the heart, lungs, liver, stomach or kidneys. Thus, the ingredients of this tea supposedly influence the heart, stomach, and liver. Ma Huang is added for its effect on lungs and bronchial system.

During the Tang Dynasty (617 A.D.-906 A.D.) many of the old prescriptions were revised and remarkable progress was made in the treatment of malaria and other fevers.

The Sung Dynasty (959 A.D.-1278 A.D.) made little, if any progress in the art of healing.

In the kingdom of Gin about 1100 A.D., however, there were two famous physicians. Li Tung-yuan specialized in disorders of the spleen and the stomach because he said that all things when taken internally must pass through the stomach and then be filtered through the spleen before going to the peripheral system. The other physician, Liu Ho-chien, opposed this theory and claimed that diseases are caused by living organisms found in the soil, and that because food is grown in soil it becomes infested with these organisms. He believed that if all food were sterilized there

would be no disease or sickness. These two physicians finally reconciled their ideas and proposed a theory of disease that became famous during their time.

Both the theories and practice of medicine seemed to take a step backward during the Yuan Dynasty (1278 A.D.-1368 A.D.). Chu Tan-kai formulated the theory of Ying and Yang, i.e. all sicknesses were believed to be either positive or negative. According to this theory, Summer diseases were positive, Winter diseases were negative and Spring and Autumn diseases were combinations of the two. It was believed that negative medicine must be used for a positive disease and vice versa. Chang Tze-ho, on the other hand, claimed that evil spirits were the cause of sicknesses and relied on prayers, incantations, and charms for their cure.

It was not until the Ming Dynasty (1368 A.D.-1643 A.D.) that medicine began to progress rapidly. Four famous professors taught in the National University during this period. Shi Lih-tsai, whose books are still used by beginners, specialized in compounding new herb formulas. Li Shi-stai stated that we really do not need herbs or drugs, because if we were to eat the right kinds of foods we would never be sick. Thus the herbs are really tonics. Chang Ching-ngoh specialized in epidemic diseases, and Li Shih-tsen divided diseases into two opposing forces. He declared that in treating a disease an herb should be used that would produce an effect opposite to that of the sickness. He discovered and used many new medicines, not only herbs from the vegetable kingdom, but also many preparations from the animal kingdom.

The last period of great discoveries of Chinese herbs was the Ching Dynasty (1644 A.D.-1911 A.D.). This dynasty contributed two great physicians. One of them, Yieh Tien-Shih, known as the "wizard physician," gained a reputation as being one who could cure any kind of ailment. According to legend, one day he passed a funeral procession, and by inquiry learned that the deceased was a pregnant woman who had suffered a strange death. Upon being granted permission to look at her, he declared that woman was not dead, but that the heart had appeared to stop because the child had seized it. With permission he stabbed a silver needle into the chest. The needle pricked the hand of the child who released its hold on the heart. The woman lived and the child was born.

The other, Chen Shiu-yuan, investigated the nine volumes of Ling Shu and selected five important prescriptions with which he effected many remarkable cures. Pan Hsia Tea was used to cure coughs caused by fevers; chi-shi-li-fang, consisting of egg whites mixed with wine, was used to cure disorders of the stomach; wu-chia-yu-ku, the pulverized powder of

"octopus bones," was used as a blood tonic and to disintegrate blood clots; and Tieh-lo was used to cure cerebral disorders and also as a blood tonic. This consisted principally of iron rust and was used because it was thought that the iron would cause the organisms to adhere to it and being heavy would sink, thereby preventing the organisms from entering the head. The fifth and last was chieh-sieh-pai-shu which supposedly caused the disappearance of phlegm in the throat and strengthened the spleen.

Since 1911 Western medicine has permeated China and now modern, scientific methods are used extensively. A National Institute of Chinese Herbs has been established for the scientific study and analysis of old Chinese remedies. Progress has been slow, but some of the results are encouraging. Many of the old remedies contain very active constituents, and it seems reasonable to believe that although the philosophy and theory of compounding Chinese prescriptions may seem strange to the Western mind, some of the Chinese preparations may prove to be of inestimable value to American and European physicians. Ephedrine has already been isolated from Ma Huang. What will be next?

University of California
College of Pharmacy
The Medical Center
San Francisco, California

# Thiamin and Symbiosis

WILLIAM J. ROBBINS

(WITH ONE FIGURE)

Schopfer (6, 7) and others (3, 5) have demonstrated that *Phycomyces Blakesleeanus* requires thiamin (vitamin $B_1$) and is unable to synthesize this growth substance from sugar, asparagine and minerals. When an agar medium lacking thiamin is inoculated with spores of *Phycomyces* the growth is extremely sparse. Although the hyphae range widely in or on the surface of the agar the individual hyphae are widely separated, no surface mat of mycelium is formed, no sporangiophores are produced and the total growth is limited to a dry weight of a milligram or less. The addition of thiamin to such a medium permits a luxuriant development; the agar becomes covered with a mycelial mat and sporangiophores are produced freely.

Some other fungi resemble *Phycomyces* in their inability to synthesize thiamin but there are many which are autotrophic for this growth substance (3). They synthesize it from elementary constituents and grow in a medium which lacks thiamin. Many of the common saprophytes, as well as some parasites, belong in this group. In fact, thiamin appears necessary for the existence of all or almost all organisms, both plant and animal, and those unable to synthesize it must secure their supply of this essential substance from that made by other organisms.[1] In other words, one part of the living world depends for thiamin upon another in somewhat the same fashion as one part depends upon the other for carbohydrates or for organic nitrogen.

The dependence of an organism heterotrophic for thiamin upon one autotrophic for the same substance is illustrated in Figure 1. In this instance a medium was prepared containing per liter 100.0 g dextrose, 1.0 g asparagine, 0.5 g $MgSO_4 \cdot 7\ H_2O$, 1.5 g $KH_2\ PO_4$ and 10 g bacto-agar. To each liter 0.1 ml of the following mineral supplements was added: 5.7 mg $H_3BO_3$, 18.6 mg $CuSO_4 \cdot 5\ H_2O$, 173 mg $FeNH_4\ (SO_4)_2 \cdot 18\ H_2O$, 8.1 mg $MnSO_4$, 4 $H_2O$, 3.6 mg ammonium molybdate 85 per cent, 79 mg $ZnSO_4$, 7 $H_2O$, distilled water 100 ml. Approximately 25 ml of this medium was poured in petri dishes and inoculated with a spore suspension of *Phycomyces*, plus strain. A scanty vegetative growth characteristic of that on a medium lacking thiamin developed. However, a colony of *Penicillium sp.* appeared as a contaminant in some of the plates. In spite

[1] This statement is not entirely correct since the successful synthesis of thiamin in vitro makes a supply available which may be used to supplement that made in vivo.

of the deficiency of thiamin this organism grew well, evidently synthesizing the necessary growth substance; its heavy mycelial mat, fruiting freely, covered a portion of the plate and overgrew the hyphae of *Phycomyces* in that portion of the agar. In two or three days *Phycomyces* sporangiophores, several centimeters long, grew up through the mat of the contaminant; but they appeared nowhere else on the plate. In the photographs in figure 1 the faint outline of the scanty growth of *Phycomyces* in the major portion of the petri dish, the heavy growth of the contaminating fungus and the sporangiophores of *Phycomyces* extending out through the

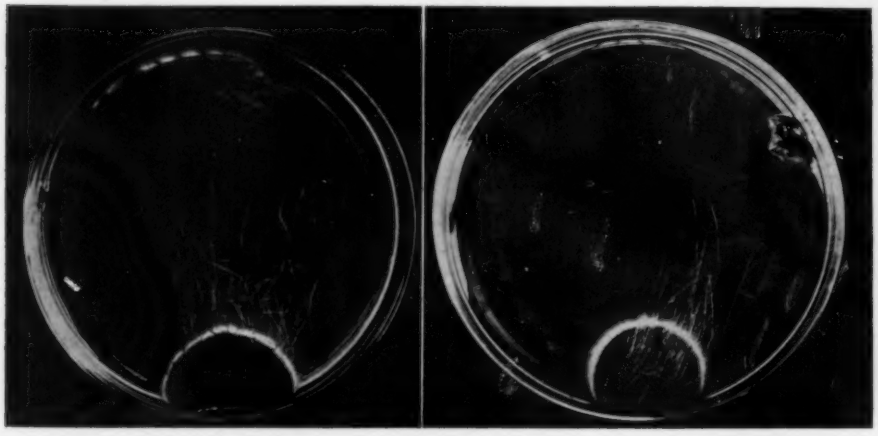

Fig. 1. Growth of *Phycomyces* on agar containing sugar, asparagine, mineral salts but no thiamin. Note scanty growth with absence of sporangiophores in major portion of plates, heavy growth of contaminating *Penicillium* and normal sporangiophores of *Phycomyces* springing from the contaminating colony. The growth on the right-hand plate is the younger.

mat of the contaminant are shown. It appears clear that the thiamin so necessary for the development of *Phycomyces* was supplied by the *Penicillium*.

It is of some interest to speculate on how the thiamin made by the *Penicillium* reached the hyphae of the *Phycomyces*. Did it diffuse from the living hyphae into the agar or did the older hyphae age, autolize and set the thiamin free? We are inclined to believe that the latter explanation is the more probable since the beneficial effect of the *Penicillium* did not extend beyond the limits of the colony as we should expect if the thiamin diffused from the normal living cells. In any event it seems clear that the *Penicillium* made more thiamin than was required for its growth and some of the excess became available for *Phycomyces*.

Others (2, 4, 8, 9, 10) have called attention to a similar relation between microorganisms autotrophic for thiamin and those heterotrophic for the same substance and have pointed out the significance of such observations for an explanation of the nutritional relations which may exist in some instances of symbiosis and parasitisin. The relation between the *Penicillium* and *Phycomyces* in this instance is not strictly symbiosis since only one organism (the *Phycomyces*) benefited; nevertheless, such observations suggest possible nutritional relationships between symbionts and between parasite and host other than those involving carbohydrate and nitrogen compounds hitherto commonly assumed.

While the growth substance involved in the example described in this paper is thiamin it should be emphasized that other growth substances may be concerned in the relationship between organisms. Kögl and Fries (1) have described instances in which one fungus supplies biotin and another thiamin, each supplementing the other's deficiencies. We will doubtless in time discover many other examples in some of which deficiencies of more than one growth substance may be supplied by the synthetic activity of organisms completely autotrophic for growth substances.

The New York Botanical Garden and
Department of Botany, Columbia University

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# INDEX TO AMERICAN BOTANICAL LITERATURE
## 1935-1939

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

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BULLETIN
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# Studies of Mexican and Central American Plants—VIII[1]

C. L. LUNDELL

(WITH FOUR FIGURES)

In studies of the Polygonaceae of the Yucatan Peninsula, preparatory to publication of an account of the polygonaceous flora of that region, a review of the Mexican and northern Central American species of *Coccoloba* has been undertaken. It is evident that Lindau's monograph (Bot. Jahrb. Engler 13: 106–229. 1890) is very outdated, and that a complete revision of the genus would be desirable to take into account the numerous species described since his treatise appeared. Interpretation of the species is often difficult for many of them are dioecious, a fact evidently overlooked by most past workers presumably because of the paucity of complete material. Staminate flowers usually are pseudohermaphroditic. Since publication of a general account of the genus will be delayed, six species from the Yucatan Peninsula are now proposed as new.

The other novelties in this paper are based primarily on material obtained by Mrs. Lundell and the writer in Yucatan and Quintana Roo, Mexico, during the summer of 1938,[2] recent collections of Mr. Percy H. Gentle in British Honduras, and collections of Mr. Eizi Matuda on Mt. Tacana, Chiapas during March and April, 1939.

In the study, types and other specimens have been borrowed from the Field Museum (F), Gray Herbarium (G), New York Botanical Garden (NY), and the Yale School of Forestry (Y); grateful acknowledgment is made to the directors and curators for this courtesy. A majority of the

[1] Papers from the Herbarium of the University of Michigan. Previous issues in this series have appeared as follows: I, Carnegie Inst. Washington Publ. 478: 208–221. 1937; II, Phytologia 1: 212–222. 1937; III, ibid. 1: 241–247. 1937; IV, Field and Laboratory 6: 9–16. 1937; V, Amer. Midland Nat. 19: 427–432. 1938; VI, ibid. 20: 236–242. 1938; and VII, Lloydia 2: 73–108. 1939.

[2] Lundell, C. L. The 1938 botanical expedition to Yucatan and Quintana Roo, Mexico. Carnegie Inst. Washington Year Book No. 37: 143–147. 1938.

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Fig. 1. *Beaucarnea Ameliae* Lundell. Note the slender erect branches and comparatively small bulbous base of trunk. The palm is a native species of *Sabal*.

cited specimens are in the University of Michigan Herbarium (M). To the Carnegie Institution of Washington and the Horace H. Rackham School of Graduate Studies of the University of Michigan the writer expresses his thanks for financial support of both field and herbarium studies.

**Beaucarnea Ameliae** sp. nov. (fig. 1).—Arbor 4–8 m. alta, basi expansa, caule 20–25 cm. diam. Folia ramorum apice congesta, linearia, basi amplexicaulia, 2.5–4.8 cm. lata, supra basin constricta, 1–1.5 cm. lata, sursum usque ad 3 cm. lata, apice setiformia, 85–105 cm. longa, minutissime serrulata. Inflorescentiae ♂ paniculatae, pyramidales, usque ad 75 cm. altae; pedicellis 5–7 mm. longis; segmentis perianthii ellipticis, 4 mm. longis, 3 mm. latis. Filamenta ca. 2 mm. longa. Antherae ca. 2.2 mm. longae. Segmenta perianthii ♀ 3–3.3 mm. longa, 1.8–2 mm. lata. Ovarium trialatum. Pedicelli fructiferi 5–9 mm. longi. Fructus 3–alatus, late ellipticus vel obovato-ellipticus, 13–18 mm. longus.

A tree 4 to 8 m. high with a thickened bulbous base contracted into a stem 20 to 25 cm. in diam. Branches erect, rather slender. Leaves clustered at apex of branches, crowded, linear, flat, the base amplexicaul, 2.5 to 4.8 cm. wide, the constriction immediately above base short, 1 to 1.5 cm. wide, the blade up to 3 cm. wide about 30 cm. above base, tapering to a long setiform tip, usually 85 to 105 cm. long, sometimes shorter, the margin microscopically serrulate with uniform appressed teeth, the grooves smooth and punctate. Staminate inflorescence (*Lundell and Lundell 8128*) entirely glabrous, openly paniculate, pyramidal, up to 75 cm. high, the lower primary branches subtended by leafy bracts up to 58 cm. long, the bracts subtending upper branches much reduced, the primary branches up to 32 cm. long; flowers in fascicles of 2 or 3, pale yellow, nearly white, subtended by thin ovate-lanceolate bracteoles 6 to 7 mm. long; pedicels jointed at or slightly below middle, 5 to 7 mm. long; perianth segments thin, elliptic, 4 mm. long, 3 mm. wide, slightly erose, reflexed at anthesis; stamens 6, opposite the perianth segments; filaments about 2 mm. long; anthers versatile, about 2.2 mm. long; ovary rudimentary. Pistillate inflorescence (*Gaumer 24327*) similar to staminate; pedicels 4 to 5 mm. long; perianth segments elliptic, entire, 3 to 3.3 mm. long, 1.8 to 2 mm. wide; stamens rudimentary, the anthers less than 1 mm. long; ovary 3–celled, 3–winged, with two erect ovules in each cell; style 3–winged; stigma thick, 3–lobed. Fruiting pedicels 5 to 9 mm. long. Fruits 1–celled, 1–seeded, 3–winged, broadly elliptic or obovate-elliptic, 13 to 18 mm. long, wings longer at apex than base, apex with an open sinus, base emarginate. Seeds shallowly 3–lobed, inaequilateral, globose, 3.5 to 4 mm. long.

Type in the Herbarium of the University of Michigan, *C. L. Lundell and Amelia A. Lundell 8128*, staminate flowers, collected in denuded lime-

stone flats bordering *cienaga*, km. 29, Merida-Progreso road, Yucatan, Mexico, July 26, 1938.

ADDITIONAL SPECIMENS EXAMINED: MEXICO: Yucatan, Kancabtsonot, Jan., 1917, *G. F. Gaumer 23520* (F); without locality, 1917-1921, *Gaumer 24327* (F); Chichen Itza, in old clearing, June 23, 1932, *W. C. Steere 1498* (M); Noh Itza, km. 104 on Merida-Chichen Itza road, a grove in advanced deciduous forest, June 15, 1938, *Lundell and Lundell 7566* (M). Quintana Roo, Coba, in fire-swept deciduous forest east of ruins, July 2, 1938, *Lundell and Lundell 7763* (M). BRITISH HONDURAS: El Cayo District, Mountain Pine Ridge, San Agustin, on crest of limestone hill bordering pineland, July 28, 1936, *Lundell 6650* (M).

DISTRIBUTION: Yucatan, Quintana Roo, and central British Honduras. It is fairly common in the xerophytic cactus area along the northwest coast of Yucatan, but only two groves were found inland, one at Noh Itza not far from Chichen Itza, and the other east of Coba in Quintana Roo. A single tree was encountered on a limestone hill at San Agustin, British Honduras, but a grove of the species was observed on a hillside near Rio Privacion, bordering the Mountain Pine Ridge.

VERNACULAR NAMES: "tsipil" (*Gaumer 23520; Lundell and Lundell 7566*); "chit" (*Steere 1498*).

*B. Ameliae* and *B. petenensis* (Lund.) Lund. resemble *B. guatemalensis* Rose. The latter has a finely scabrous leaf surface, a well marked characteristic apparently not observed by Rose (Contr. U. S. Nat. Herb. **10**: 88. 1906). The two peninsula species have entirely smooth blades. *B. petenensis* is known only from sterile material, but appears amply distinct from *B. Ameliae* in its leaves which are 115 to 140 cm. long compared with 85 to 105 cm. long in the latter. The narrow prolonged constriction above the base of the leaf and a maximum blade width of only 2 cm. distinguish it further.

**Beaucarnea petenensis** (Lundell) comb. nov. *Dracaena petenensis* Lundell, Journ. Wash. Acad. Sci. **25**: 230. 1935.—A tree 6 to 12 m. high with a thick bulbous base 70 to 90 cm. in diam.; trunk 20 to 30 cm. in diam. Branchlets 10 to 15 mm. in diam. 15 cm. below apex. Leaves numerous, crowded at apex of branchlets, pendent, linear, flat, the base amplexicaul, up to 3.5 cm. wide, the constriction immediately above base elongate, about 7 mm. wide, the blade up to 2 cm. wide 30 cm. above base, tapering to a long setiform tip, usually 115 to 140 cm. long, the margin microscopically serrulate with uniform subappressed teeth, the grooves smooth. Flowers and fruits unknown.

SPECIMEN EXAMINED: GUATEMALA: Department of Petén, Monte Hiltun, a grove in limestone valley forest, May 17, 1933, *Lundell 3271*, type (M).

No fertile material of this species has been collected, but its habit and leaf characteristics are those of a *Beaucarnea*.

**Nolina pliabilis** (Baker) comb. nov. *Dasylirion pliabile* Baker, Journ. Linn. Soc. Bot. **18**: 240. 1880. *Beaucarnea pliabilis* (Baker) Rose, Contr. U. S. Nat. Herb. **10**: 89. 1906.—Reported to be a tree. Leaves rather thick, rigid, linear, concave, the base amplexicaul, about 17 mm. wide, constricted above into a narrow blade 3 to 4 mm. wide, possibly 60 cm. long, the margin armed with irregularly spaced incurved prickles visible to the naked eye, the grooves very narrow, microscopically papillate. Pistillate flowers usually geminate with an undeveloped third bud, subtended by thin, keeled, ovate, erose bracteoles 2 to 2.5 mm. long; pedicels jointed above the middle, about 2.5 mm. long, accrescent rapidly after anthesis becoming 4 to 5 mm. long with joint below middle; perianth segments entire, thin, ovate-oblong or oblong-elliptic, 2 to 2.1 mm. long, 1 to 1.2 mm. wide, apex papillate; stamens rudimentary, much shorter than perianth segments; ovary 3–celled, 3–lobed with 2 ovules in each cell; stigma subsessile, small, 3–lobed. Immature fruits deeply 3–lobed, the lobes rounded, divaricate, usually with 1 ovule developing in each cell.

SPECIMEN EXAMINED: MEXICO: Yucatan, in littoral area near Sisal, Oct. 24, 1865, *Arthur Schott 892*, type collection (F).

VERNACULAR NAME "tzipil."

Baker (l. c.) described the species as having leaves up to 15 mm. wide and 60 cm. long, with fruiting pedicels about 3 mm. long, and fruits broadly elliptic, about 13 mm. long, 8.5 to 9.5 mm. wide. The Schott specimen in the Field Museum Herbarium bears a single broken leaf 4 mm. wide, and has pedicels up to 5 mm. long. I have not seen the type specimen which is in the British Museum Herbarium; my interpretation of the species is based on the cited isotype.

Rose (l.c.) evidently did not see type material of *N. pliabilis*, and confused the species with *Beaucarnea Ameliae* Lundell. The leaves, flowers and fruits of *Schott 892* (F) are typical of the genus *Nolina*.

**Coccoloba corozalensis** sp. nov. (fig. 2).—Arbor, 10–15 cm. diam. Ramuli glabri. Folia petiolata, petiolo 5–11 mm. longo, glabra, chartacea vel subcoriacea, ovato-elliptica, late elliptica vel obovata, 5–12 cm. longa, 2.5–7.3 cm. lata, apice rotundata vel raro late obtusa, basi rotundata, raro subcuneata, minute reticulato-venosa. Inflorescentiae terminales, spicatae vel subspicatae, 7–14 cm. longae, pedunculis 2 cm. longis vel minoribus, rachidibus glabris,

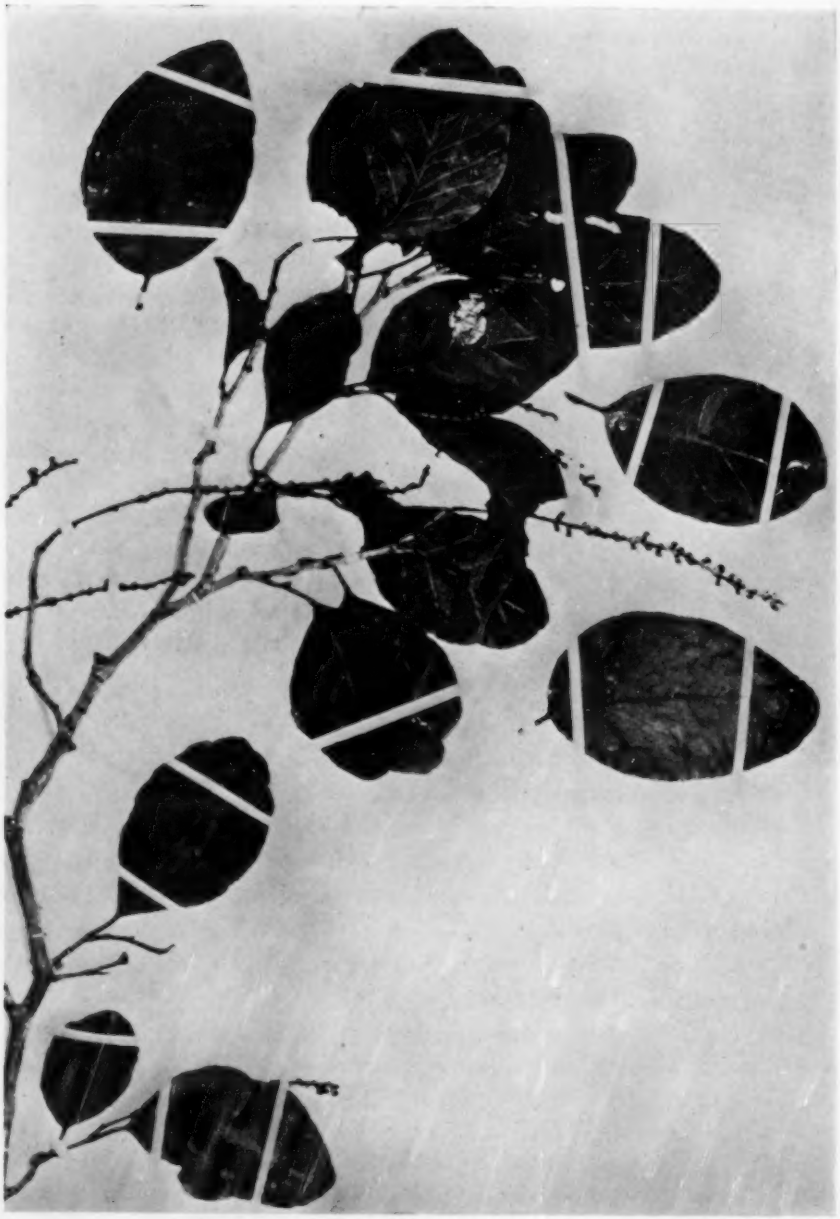


Fig. 2. *Coccoloba corozalensis* Lundell. Type (*Lundell 4908*), in Herbarium of the University of Michigan. ×½.

nodulis 1–floris, raro 3–floris; bracteae ca. 1 mm. longae; ochreolae bracteam superantes. Flores dioici, subsessiles. Perianthii ♀ tubus cylindricus, 1 mm. longus, lobis oblongo-ellipticis vel ovato-ellipticis, rotundatis, 1–1.4 mm. longis. Stamina abortiva. Ovarium 1.2–1.5 mm. longum. Styli 3, exserti. Pedicelli fructiferi ochreolis breviores. Fructus ovoideus, 7–9 mm. longus, 5–6 mm. diam., basi rotundatus, apice obtuse acuminatus.

A tree 10 to 15 cm. in diam.; branchlets glabrous, rather short and slender. Stipules 5 to 9 mm. long, glabrous, thin, the tube tightly sheathing stem, petiole basal. Leaf blades entirely glabrous, chartaceous at first, subcoriaceous with age, ovate-elliptic, broadly elliptic or obovate, 5 to 12 cm. long, 2.5 to 7.3 cm. wide, apex rounded or rarely bluntly obtuse, base usually rounded, sometimes decurrent and subcuneate, costa prominent beneath, nearly plane above, main lateral veins 5 to 8 on each side, veinlets finely and closely reticulate, veins and veinlets prominulous on both surfaces. Petioles sulcate, glabrous, 5 to 11 mm. long. Inflorescence terminal, spicate or subspicate, 7 to 14 cm. long, few flowered, glabrous; peduncles up to 2 cm. long; rachis slender; nodules usually 1–flowered, sometimes 3–flowered (*Kluge 17*); bracts broad, rounded, about 1 mm. long; ochreolae slightly exceeding bracts, thin, truncate, bracts and ochreolae bearing within a few short red hairs. Flowers dioecious, subsessile at anthesis, the pedicels accrescent. Pistillate flowers: perianth tube cylindrical, 1 mm. long, thick; lobes oblong-elliptic or ovate-elliptic, rounded, 1 to 1.4 mm. long. Stamens rudimentary, 0.5 mm. long or less. Ovary slender, 1.2 to 1.5 mm. long; styles 3, 1 to 1.2 mm. long; stigmas exserted. Fruiting pedicels shorter than ochreolae. Fruits purple-black when ripe (*Bartlett 11281*), ovoid, 7 to 9 mm. long, 5 to 6 mm. in diam., base rounded, apex obtusely acuminate, the acumen formed by the persistent perianth lobes.

Type in the Herbarium of the University of Michigan, *C. L. Lundell 4908*, collected in *acahual*, Xiabe, Corozal District, British Honduras, Aug. 21, 1933.

Additional specimens examined: BRITISH HONDURAS: Corozal District, Xiabe, Aug. 21, 1933, *Lundell 4908*, type collection (F-2). Orange Walk District, Honey Camp, Sept., 1929, *Lundell 347* (F). Belize District, Maskall, in hammock in pineland, Jan. 31, 1934, *Percy H. Gentle 1113* (F, M). Cornhouse Creek, in thicket above mangrove between river and pine ridge, Jan. 31, 1931, *H. H. Bartlett 11281* (M). Without locality, *Kluge 17* (Y).

Distribution: Coastal areas of northern and central British Honduras.

Vernacular names: "uva cimarron" (*Lundell 4908*); "pigeon plum" (*Gentle 1113*); "wild grape" (*Kluge 17*).

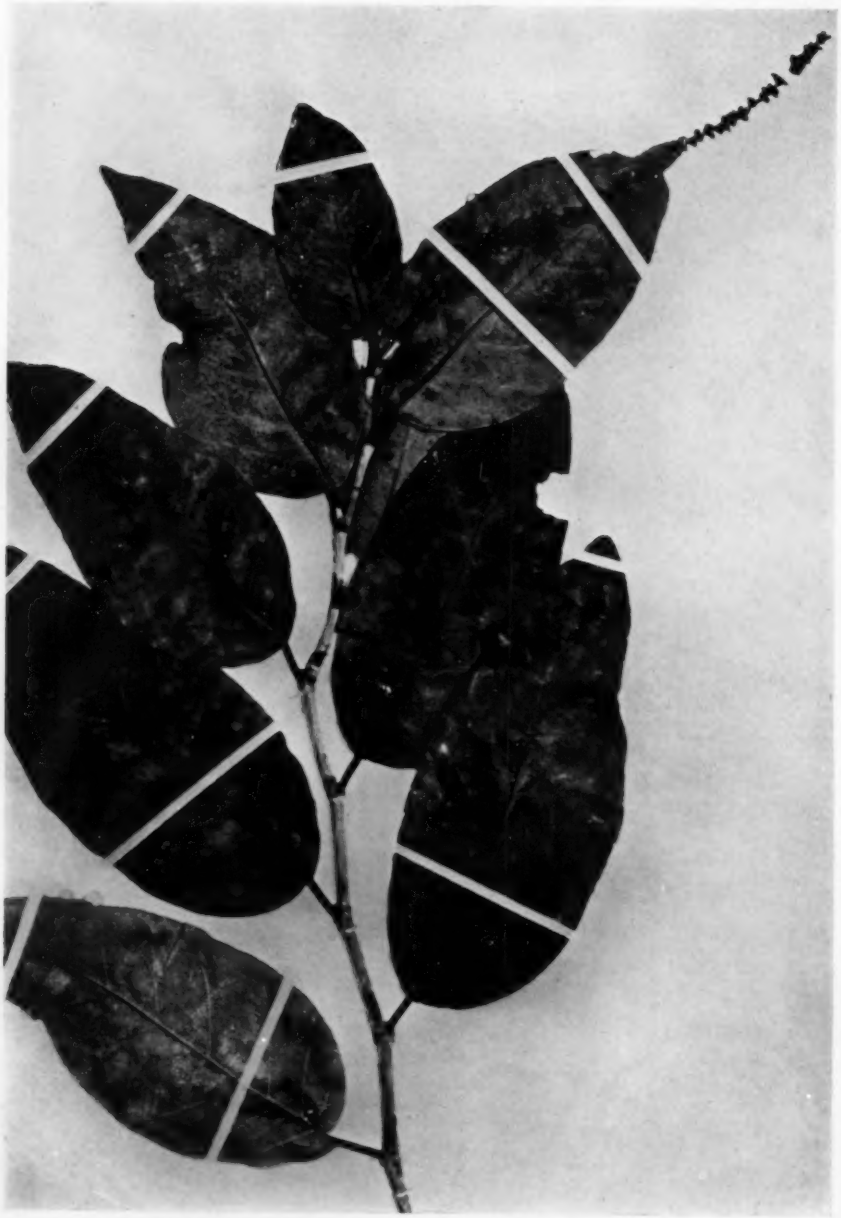


Fig. 3. *Coccoloba Gentlei* Lundell. Type (*Gentle 56*), in Herbarium of the University of Michigan. ×½.

**Coccoloba Gentlei** sp. nov. (fig. 3).—Arbor parva. Ramuli glabri. Folia petiolata, petiolo 9–12 mm. longo, glabra, subcoriacea, lanceolata vel lanceolato-elliptica, 7–13.5 cm. longa, 3.5–6.2 cm. lata, apice attenuata, late obtusa vel rotundata, basi rotundata, reticulato-venosa. Inflorescentiae terminales, subpaniculatae, 12–16 cm. longae; spicae compositae, rachidibus glabris, nodulis 1–4–floris; bracteae 1–1.4 mm. longae, glabrae; ochreolae bracteam superantes, glabrae. Flores subsessiles vel breviter pedicellati. Perianthii tubus ca. 1 mm. longus, lobis oblongo-ellipticis, 1.8–2 mm. longis. Ovarium 1–1.2 mm. longum, ut videtur abortivum. Styli 3.

A small tree; branchlets glabrous, striate. Stipules 12 to 13 mm. long, thin, glabrous, the tube tightly sheathing stem, petiole basal. Leaf blades subcoriaceous, entirely glabrous, lanceolate or lanceolate-elliptic, 7 to 13.5 cm. long, 3.5 to 6.2 cm. wide, apex attenuate, bluntly obtuse or rounded, base rounded, costa prominent beneath, nearly plane above, main lateral veins 8 to 11 on each side, rather prominent beneath, less conspicuous above, finely and closely reticulate-veined on both surfaces. Petioles thick, sulcate above, glabrous, 9 to 12 mm. long. Inflorescence terminal, subpaniculate, the central spike 12 to 16 cm. long, bearing 1 or 2 short lateral spikes near base, exceeding leaves; rachis slender, glabrous; nodules 1– to 4–flowered; bracts broad, rounded, 1 to 1.4 mm. long, glabrous; ochreolae exceeding bracts, up to 2 mm. long, truncate, glabrous. Flowers subsessile or with pedicels up to 1 mm. long, shorter than ochreolae. Perianth glabrous, tube about 1 mm. long; lobes oblong-elliptic, 1.8 to 2 mm. long, rounded. Filaments subequaling lobes. Ovary obscurely trigonal, slender, 1 to 1.2 mm. long (abortive?); styles 3. Fruits not known.

Type in the Herbarium of the University of Michigan, *Percy H. Gentle 56*, collected along Belize-Sibun River road, Belize District, British Honduras, 1931–1932. Duplicate in Field Museum Herbarium.

The species is related to *C. corozalensis* Lundell.

**Coccoloba hondurensis** sp. nov.—Arbor, 13 m. alta. Ramuli glabri, striati. Folia petiolata, petiolo 1–3.5 cm. longo, glabra, subcoriacea vel coriacea, oblongo-elliptica, ovato-oblonga vel obovato-elliptica, 8.5–29 cm. longa, 4–16 cm. lata, apice obtuse apiculata, obtusa, vel abrupte subacuminata, acumine obtusa vel raro acuta, basi obtuso-rotundata, rotundata vel emarginata, reticulato-venosa. Inflorescentiae terminales, simplices vel subpaniculatae, racemosae, 15–45 cm. longae, rachidibus puberulis, nodulis 1–3–floris; bracteae ovato-triangulares, ca. 0.8 mm. longae, puberulae; ochreolae bracteam subaequantes, puberulae. Flores albi, subsessiles; pedicelli fructiferi ca. 2 mm. longi. Perianthii tubus 0.9–1 mm. longus, lobis suborbicularibus vel late ovato-oblongis, 1–1.4 mm. longis. Filamenta 1.4–2.5 mm. longa. Ovarium trigonum, ca. 1 mm.

longum. Styli 3. Fructus subglobosus vel ellipsoideus, 7–12 mm. longus, 7–8 mm. diam., apice basique obtusus vel rotundatus.

A tree up to 13 m. high; branchlets glabrous, striate. Stipules sheathing, ample, up to 13 mm. long, at first puberulent and barbate, glabrescent very early, petiole basal. Leaf blades entirely glabrous, subcoriaceous or coriaceous, oblong-elliptic, ovate-oblong or obovate-elliptic, 8.5 to 29 cm. long, 4 to 16 cm. wide, apex obtusely apiculate, obtuse or abruptly subacuminate, the acumen usually obtuse, sometimes acute, base obtuse-rounded, rounded or emarginate, often inaequilateral, costa prominent beneath, nearly plane at base above, main lateral veins 6 to 10 on each side, prominent beneath, less conspicuous above, finely reticulate-veined on both surfaces. Petioles thick, glabrous, 1 to 3.5 cm. long. Inflorescence terminal, simple or subpaniculate, racemose, 15 to 45 cm. long; rachis minutely and densely puberulent; nodules 1– to 3–flowered; bracts ovate-triangular, about 0.8 mm. long in flower, up to 1.4 mm. long in fruit (*Chickering 233*), obtusish to acute, puberulent; ochreolae subequaling to slightly exceeding bracts in length, puberulent. Flowers white (Bartlett), subsessile, the pedicels lengthening after anthesis, up to 2 mm. long in fruit. Perianth finely lepidote, the tube 0.9 to 1 mm. long; lobes suborbicular or broadly ovate-oblong, 1 to 1.4 mm. long. Filaments 1.4 to 2.5 mm. long. Ovary trigonal, about 1 mm. long; styles 3. Fruits dull pale purple, subglobose or ellipsoid, 7 to 12 mm. long, 7 to 8 mm. in diam., apex and base obtuse or rounded.

Type in the Herbarium of the University of Michigan, *C. L. Lundell 3996*, collected on river bank at Little Cocquericot, Belize River, El Cayo District, British Honduras, June 12, 1933.

ADDITIONAL SPECIMENS EXAMINED: **BRITISH HONDURAS**: El Cayo District, Little Cocquericot, Belize River, April 30, 1933, *Lundell 3995* (F, M); May 25, 1933, *Lundell 3997* (F, M). Belize District, Manatee Lagoon, Dec. 30, 1905, *M. E. Peck 255* (G). Cornhouse Creek, Manatee River, Jan. 31, 1931, *H. H. Bartlett 11275* (F, M). Sibun River, Feb. 4, 1931, *Bartlett 11361* (M). Tiger Point, Northern River, *Percy H. Gentle 897* (F, NY, M). Stann Creek District, Silk Grass Creek Reserve, Jan. 1, 1926, *S. J. Record* (*B. H. 20, Yale 8788*) (Y). Middlesex, along river bank, Nov. 15, 1929, *W. A. Schipp 453* (F, M, NY). **GUATEMALA**: Department of Izabal, vicinity of Quirigua, alt. 75–225 m., May 15–31, 1922, *P. C. Standley 23988, 24547, 24601* (NY). **HONDURAS**: Department of Santa Barbara, San Pedro Sula, March, 1889, *C. Thieme* (*Donn. Smith 5433*) (F). Department of Atlantida, vicinity of Tela, at sea level, 1927–1928, *P. C. Standley 53716, 54476, 54481, 54752, 56598, 56659* (F). East of Tela, near lagoon, June-July, 1929, *A. M. Chickering 233* (F, M).

DISTRIBUTION: Wet lowlands of central and southern British Honduras, eastern Guatemala, and northern Honduras. It has been found chiefly on river banks and in wooded swamps of the coastal areas.

VERNACULAR NAMES: "uva" (*Standley 53716*); "cordoncillo" (*Standley 24601*); "wild grape" (*Record B. H. 20*).

The specimens show considerable variation, especially in leaf shape, inflorescence, and fruits, but all appear to be referable to a single species. The flowers are dioecious, but the pistillate ones available are not in satisfactory condition for description. Collections of *C. hondurensis* have been referred to *C. Schiedeana* Lindau, *C. marginata* Benth., *C. barbadensis* Jacq., and *C. leptostachya* Benth. I have not been able to associate the species with any of these.

**Coccoloba lancifolia** sp. nov.—Arbor, 8 m. alta, 12.5 cm. diam. Ramuli glabri. Folia petiolata, petiolo 5–10 mm. longo, glabra, chartacea vel subcoriacea, lanceolata vel lanceolato-oblonga, 4.5–7.5 cm. longa, 1.8–3.3 cm. lata, apice attenuata, obtusa vel obtuse acuminata, basi rotundata, reticulato-venosa. Infructescentiae terminales, racemosae, rachidibus glabris, nodulis 1–3–floris; bracteae et ochreolae minutae, glabrae. Pedicelli fructiferi crassi, 2.5–3.5 mm. longi. Fructus ovoideus, 11–12 mm. longus, 7–9 mm. diam., apice obtuse apiculatus.

A tree, 12.5 cm. in diam., 8 m. high; branchlets glabrous, short. Stipules closely sheathing, 3 to 6 mm. long, petiole basal. Leaf blades entirely glabrous, chartaceous or subcoriaceous, lanceolate or lanceolate-oblong, 4.5 to 7.5 cm. long, 1.8 to 3.3 cm. wide, apex attenuate, obtuse or obtusely acuminate, base rounded, slightly emarginate or decurrent, inconspicuously inaequilateral, costa prominent beneath, plane above at base, main lateral veins 4 to 6 on each side, reticulate-veined, veins and veinlets prominulous on both surfaces. Petioles slender, sulcate above, 5 to 10 mm. long, glabrous. Infructescence terminal, racemose, shorter than leaves, entirely glabrous; bracts and ochreolae glabrous, minute; nodules 1– to 3–flowered. Fruiting pedicels stout, 2.5 to 3.5 mm. long. Fruits smooth, yellow (Schipp), ovoid, 11 to 12 mm. long, 7 to 9 mm. in diam., apex obtusely apiculate, crowned by the persistent perianth lobes, contracted slightly at base.

Type in the Herbarium of the University of Michigan, *W. A. Schipp 1200*, collected on hilltop in forest shade, Jacinto Hills, Toledo District, British Honduras, Aug. 28, 1933. Duplicates in Gray Herbarium and Field Museum Herbarium.

*C. lancifolia* is near *C. laurifolia* Jacq., but differs in its small lanceolate pointed leaves.

COCCOLOBA LAURIFOLIA Jacq., Hort. Schoenbr. 3: 9, t. 267. 1798. This species, widely distributed from Florida through the West Indies to Venezuela, apparently has not been recorded from Central America. Two collections, referable here, are at hand from northern British Honduras: *Percy H. Gentle 231* (F, M), Corozal District, 1931–1932; *C. L. Lundell 4945* (F, M), in high ridge, Consejo, Corozal District, Aug. 30, 1933. Locally it is known as "wild grape."

**Coccoloba Schippii** sp. nov.—Arbor, 10 m. alta, 15 cm. diam. Ramuli glabri, striati. Folia petiolata, petiolo 9–14 mm. longo, glabra, chartacea, lanceolata, 8–12.5 cm. longa, 3–5 cm. lata, apice longe acuminata, basi rotundata vel anguste rotundata, minute reticulato-venosa. Inflorescentiae terminales vel laterales, ut videtur spicatae, rachidibus puberulis, nodulis 1–floris; bracteae ovato-oblongae, ca. 1 mm. longae, extus hirsutae; ochreolae bracteam superantes. Alabastra sessilia vel subsessilia, glabra.

A tree 15 cm. in diam., 10 m. high; branchlets slender, entirely glabrous, striate, drying black. Stipules sheathing, barbate at apex, glabrous otherwise, petiole basal. Leaf blades entirely glabrous, chartaceous, lanceolate, 8 to 12.5 cm. long, 3 to 5 cm. wide, apex long acuminate, base rounded or narrowed and rounded, costa prominent beneath, slightly elevated above, main lateral veins 6 or 7 on each side, prominulous beneath, slightly less conspicuous above, minutely reticulate-veined on both surfaces. Petioles slender, drying black, glabrous, canaliculate, 9 to 14 mm. long. Inflorescence terminal or lateral, 2.5 to 4.5 cm. long (in bud), apparently spicate; rachis puberulent, hirsute at base of bracts; nodules 1–flowered; lower bract 2 mm. long, clawed, upper bracts ovate-oblong, about 1 mm. long, hirsute on outside; ochreolae campanulate, thin, with rounded lobes, exceeding the upper bracts, up to 1.8 mm. long, puberulent on outside, bearing some longer hairs. Flower buds sessile or subsessile, glabrous; perianth lobes ovate or elliptic, rounded at apex. Stigmas 3.

Type in the Herbarium of the Field Museum of Natural History, No. 733,663, *W. A. Schipp S–687*, collected in forest shade at Camp 31 of the British Honduras-Guatemala boundary survey, in Toledo District, British Honduras, Mar. 18, 1934; alt. about 675 m.; fragment of type and a photograph in the Herbarium of the University of Michigan.

*C. Schippii* appears to be related to *C. guyanensis* Meissn. of South America.

**Coccoloba spicata** sp. nov. (fig. 4).—Arbor, 5–16 m. alta, 10–20 cm. diam. Ramuli glabri. Folia petiolata, petiolo 1–2.3 cm. longo, coriacea, supra glabra, subtus ad costam et in axillis pilosa, late ovata vel oblongo-elliptica, 6.5–15 cm. longa, 4–10 cm. lata, apice anguste rotundata, obtusa, vel late

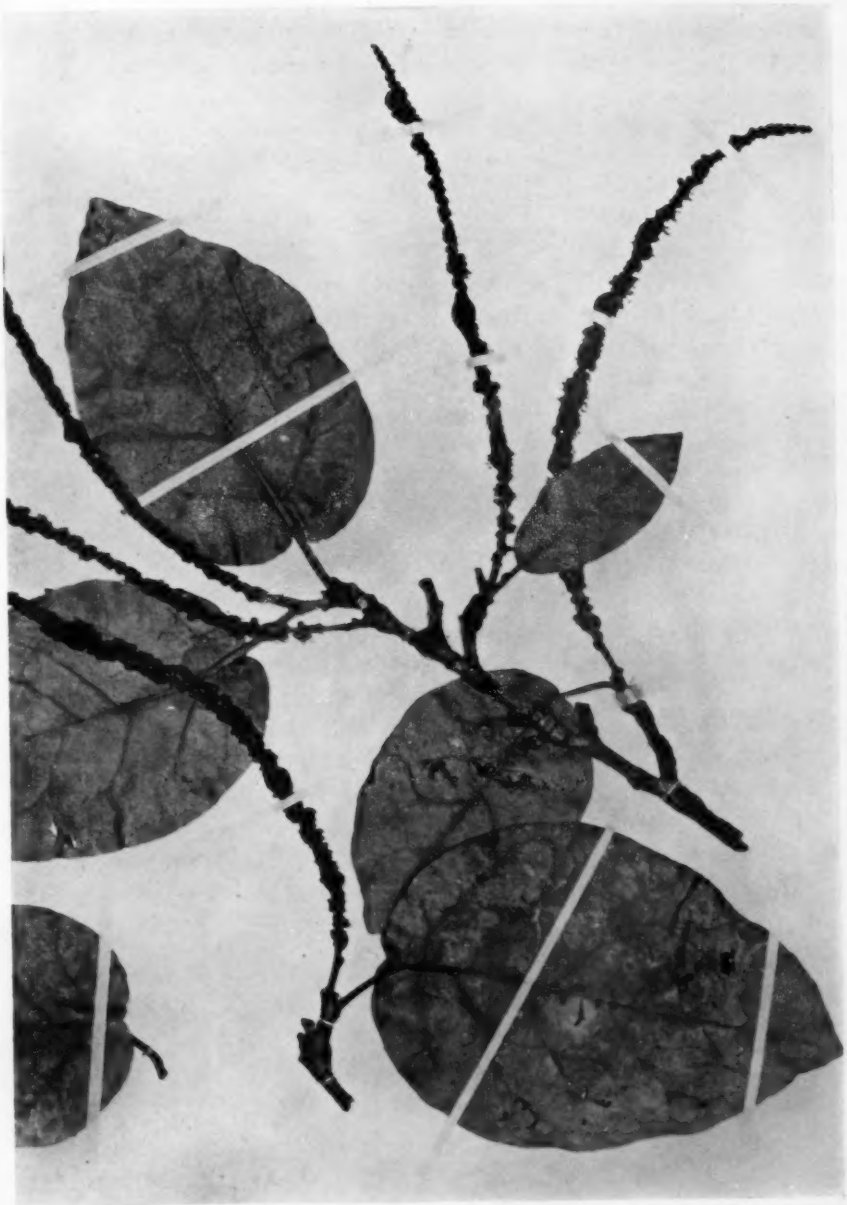


Fig. 4. *Coccoloba spicata* Lundell. Type (*Lundell and Lundell 7325*), in Herbarium of the University of Michigan. ×½.

obtuse apiculata, basi late rotundata, cordata vel emarginata. Inflorescentiae terminales, spicatae, 8.5–25 cm. longae, rachidibus glabris vel puberulis, nodulis 1–2–floris; bracteae hirtellae, 1–1.2 mm. longae; ochreolae bracteam aequantes vel superantes, hirtellae, apice barbatae. Flores et fructus sessiles. Perianthii tubus ca. 1 mm. longus, lobis late ovatis vel suborbicularibus, ca. 2 mm. longis. Ovarium ca. 1 mm. longum, ut videtur abortivum. Styli 3. Fructus late ovoideus vel subglobosus, ca. 7 mm. longus, 6 mm. diam., apice basique rotundatus, obscure costatus.

A tree, 10 to 20 cm. in diam., 5 to 16 m. high; branchlets glabrous. Stipules lax, usually 5 to 9 mm. long, sometimes larger, rufous hirsute at first, glabrescent early, petioles usually basal, sometimes medial to subapical. Leaf blades barbate beneath in the axils of the primary veins and short hairy along the costa, glabrous otherwise, coriaceous to rigidly coriaceous, broadly ovate or oblong-elliptic, 6.5 to 15 cm. long, 4 to 10 cm. wide, juvenile blades up to 29 cm. long, 21 cm. wide, apex slightly narrowed and rounded, obtuse, or broadly obtuse apiculate, base broad and round, deeply cordate to emarginate, costa prominent beneath, thick at base, less conspicuous above, primary veins 5 to 7 on each side, prominent on undersurface, less conspicuous above, veinlets scarcely evident above, minutely but obscurely reticulate below. Petioles thick, puberulent at top above, otherwise glabrous, 1 to 2.3 cm. long. Inflorescence terminal, spicate, 8.5 to 25 cm. long; rachis glabrous or puberulent; nodules 1– or 2–flowered; bracts hirtellous, ovate-triangular, rounded, 1 to 1.2 mm. long; ochreolae equaling or exceeding bracts, hirtellous, sometimes barbate at apex. Flowers and fruits sessile, crowded. Perianth pale green usually glabrous, sometimes puberulent, the tube about 1 mm. long; lobes broadly ovate or suborbicular, about 2 mm. long. Filaments about 2 mm. long. Ovary trigonal, about 1 mm. long (abortive?); styles 3. Fruits (*Lundell 560*) broadly ovoid or subglobose, about 7 mm. long and 6 mm. in diam., apex and base rounded, slightly costate.

Type in the Herbarium of the University of Michigan, *C. L. Lundell and Amelia A. Lundell 7325*, collected in young legume thicket around Sacred Cenote, Chichen Itza, Yucatan, Mexico, May 13, 1938.

Additional specimens examined: MEXICO: Yucatan, Izamal, Sept., 1895, *G. F. Gaumer 819* (F). Kancabtsonot, May, 1917, *Gaumer and sons 23894* (F). Without locality, 1917–1921, *Gaumer 23976* (F, NY). Chichen Itza, June 28, 1929, *J. Bequaert 103* (F). Valladolid, 1935, *Ramon S. Flores* (F). Without locality, 1937, *Morris Steggerda 1B* (F). Quintana Roo, Coba, in relic deciduous forest east of ruins, July 4, 1938, *Lundell and Lundell 7813* (M). BRITISH HONDURAS: Corozal District, Santa Rita, in *acahual*, Sept. 14, 1933, *Lundell 4951* (F, M, NY). Orange Walk District, Honey Camp, Oct., 1929, *Lundell 560* (F, NY).

DISTRIBUTION: In dry deciduous upland forest of Yucatan, Quintana Roo, and northern British Honduras.

VERNACULAR NAMES: "bob" (*Lundell and Lundell 7813, Flores* in 1935); "xbobche" (*Gaumer 819*); "boob" (*Steggerda 1B*); "wild grape" (*Lundell 4951*).

ECONOMIC USES: The large juvenile leaves are utilized in Valladolid for wrapping a sweet called "mercocha" (*Flores*).

The species is related to *C. mayana* Lundell. A collection from Champoton, Campeche, *Flores* in 1934 (F), evidently taken from a tree cultivated for shade, locally known as "bochiche," may be referable here. It differs most obviously from *C. spicata* in having slender puberulent branchlets and oblong leaves.

**Heliocarpus horridus** sp. nov.—Arbor parva, 5–metralis, omnino persistenter minute rufo-glandulosa. Folia integra, late ovata vel suborbicularia, 7–15.5 cm. longa, 4–10.3 cm. lata, apice caudato-acuminata, basi subcordata, serrata, supra parce hirsuta, subtus breviter stellato-hirsuta; petiolis 2.7–4 cm. longis, supra hirsutis. Infructescentiae parvae, rachidibus hirsutis et dense glandulosis. Pedicelli fructiferi 4–4.5 mm. longi. Fructus crasse stipitatus.

A small tree 5 m. high; all parts clothed with minute reddish glands, blackish with age; branchlets covered with glands, glabrous otherwise. Leaves integral, thin, broadly ovate or suborbicular, 7 to 15.5 cm. long, 4 to 10.3 cm. wide, apex caudate-acuminate, base subcordate, serrate, teeth obtuse, the basal glandular, upper surface sparsely hirsute with simple or few-branched hairs, lower surface short hirsute with denser stellate hairs, palmately 5–veined; petioles 2.7 to 4 cm. long, hirsute above, densely so at base of blade. Panicles small, the branches hirsute and densely glandular. Fruiting pedicels 4 to 4.5 mm. long, jointed at the middle. Fruits with stout stipe 4 to 5 mm. long; body ellipsoid, the faces deeply rugose, sparingly hirsute, bearing 3 to 6 plumose bristles subequaling those of fringe; plumose bristles of fringe as much as 6.5 mm. long, extending down the stipe.

Type in the Herbarium of the University of Michigan, *C. L. Lundell and Amelia A. Lundell 7821*, collected in relic forest east of Coba, Quintana Roo, Mexico, July 5, 1938; vernacular name "holol."

*H. horridus* is noteworthy primarily for the long plumose bristles on the faces of the fruits. The abundant minute reddish or blackish glands covering all parts, the broad ovate leaves rather sparsely short hirsute on both surfaces, the fruiting pedicels jointed at the middle, and the small panicles distinguish it further. It is related to *H. glanduliferus* Rob.

**Cassipourea belizensis** sp. nov.—Arbor, 25 cm. diam.; ramulis crassiusculis, strigillosis. Folia petiolata, petiolo 3–8 mm. longo, strigilloso, late elliptica, 4.5–8.5 cm. longa, 2.6–5.5 cm. lata, apice abrupte subacuminata, acuta vel obtusa, basi late cuneata, subcoriacea, integra, venis lateralibus 5–7. Flores fasciculati, pedicellis strigillosis, usque ad 4 mm. longis. Calyx abrupte stipitatus, glaber vel subglaber, tubo ca. 3 mm. longo, quinquelobato, lobis ovatis, 1.7–2 mm. longis. Petala ca. 7.5 mm. longa, villosa. Stamina usque ad 5.5 mm. longa. Ovarium 3–loculare.

A tree, diam. 25 cm.; branchlets rather stout, at first covered with short appressed hairs, glabrescent early. Leaves petiolate, the petioles stout, grooved, 3 to 8 mm. long, short appressed hairy, the blades broadly elliptic, 4.5 to 8.5 cm. long, 2.6 to 5.5 cm. wide, apex abruptly subacuminate, acute or obtuse, base broadly cuneate, subcoriaceous, with a few appressed short hairs at base and along margin, glabrous otherwise, entire or essentially so, costa prominent beneath, slightly raised above, main lateral veins 5 to 7, veins and veinlets prominulous. Fowers fascicled, distinctly stalked. Pedicels appressed hairy, up to 4 mm. long (not including stipe). Calyx abruptly contracted at base into a stipe about 1 mm. long, with a few appressed hairs outside or entirely glabrous, tube about 3 mm. long, 5–lobed, the lobes deltoid-ovate, 1.7 to 2 mm. long, sericeous within, short tomentose at apex along margin of lobes. Petals about 7.5 mm. long, the blade short villous on both surfaces, the fringe villous. Stamens up to 5.5 mm. long. Ovary depressed-globose, glabrous below, sericeous above, 3–celled. Style sericeous.

Type in the Herbarium of the University of Michigan, *Percy H. Gentle 2749*, collected in *acahual* near Sarawee Pine Ridge, Stann Creek District, British Honduras, April 13, 1939; vernacular name "waterwood."

From the other British Honduran species, identified by P. C. Standley as *C. podantha* Standl., *C. belizensis* differs conspicuously in leaf form. In *C. podantha* the leaves are much narrower, long acuminate, and often distinctly toothed. In *C. belizensis* the blade of the petals is short villous whereas it is quite glabrous in the other species.

**Turpinia tricornuta** sp. nov.—Arbor; ramulis crassis. Folia pinnata, petiolata, petiolo usque ad 6 cm. longo; foliola glabra, coriacea, 5 vel 7, raro 2, 3 vel 4, oblongo-elliptica vel ovato-elliptica, 4.5–13.5 cm. longa, 2.4–7 cm. lata, apice abrupte acuminata, basi rotundata, serrata, venis lateralibus 6–9. Inflorescentiae axillares, paniculatae, pauciflorae, usque ad 8.5 cm. longae. Pedicelli crassi, minute puberuli, usque ad 6 mm. longi. Sepala ciliolata, inaequalia, 3 exteriora late ovata vel elliptica, 2.5–5 mm. longa, 2 interiora late elliptica vel obovato-elliptica, 5.5–7 mm. longa. Petala obovato-spathulata, 5–6.5 mm.

longa, intus parce pilosa, basi ciliata, apice eroso-ciliolata. Filamenta crassa, usque ad 5.2 mm. longa, 1 mm. lata, glabra. Ovarium villosum. Fructus ad mediam tricornutus.

A tree; branchlets thick, terete, reddish, minutely and sparsely puberulent around the nodes at first, glabrous early, the bark scaling off longitudinally. Leaves opposite, pinnate, petiolate, the petioles up to 6 cm. long, terete; petiolules of lateral leaflets up to 1.8 cm. long, canaliculate; leaflets usually 5 or 7, sometimes 2, 3 or 4, oblong-elliptic or ovate-elliptic, 4.5 to 13.5 cm. long, 2.4 to 7 cm. wide, apex abruptly acuminate, base often inaequilateral, usually rounded, sometimes rounded and abruptly acutish, entirely glabrous, coriaceous, serrate, costa prominent beneath, raised above as a fine narrow line or nearly plane, main lateral veins 6 to 9 on each side, widely arcuately ascending, prominulous on under surface. Inflorescence axillary, paniculate, small, few-flowered, up to 8.5 cm. long, usually not exceeding the petiole, sparsely and very minutely puberulent. Pedicels stout, minutely and sparsely puberulent, up to 6 mm. long, jointed at base. Sepals unequal, rather thick, ciliolate, the three outer broadly ovate or elliptic, 2.5 to 5 mm. long, the two inner broadly elliptic to obovate-elliptic, 5.5 to 7 mm. long. Petals obovate-spathulate, clawed, 5 to 6.5 mm. long, hairy along the midvein inside, the basal half ciliate, the upper half erose-ciliolate. Filaments thick, up to 5.2 mm. long, 1 mm. wide; anthers cordate, about 1.5 mm. long, blunt at apex. Disk shallowly lobed. Ovary villous, 3-celled at base, the carpels free above; the 3 styles united at apex, free below. Drupe tricornute almost to the middle, the lobes divaricate, thick at base, tapering to the persistent style.

Type in the Herbarium of the University of Michigan, *Eizi Matuda 2941*, collected on north side of Mt. Tacana, Chiapas, Mexico, April 2, 1939; alt. 2100 m.

The large coriaceous leaflets, small few-flowered narrow panicles of comparatively large flowers, ciliate petals, villous ovary, and the tricornute drupes mark the species. Its affinity is with *T. occidentalis* G. Don.

**Ternstroemia impressa** sp. nov.—Arbor 10–12 m. alta, 30 cm. diam. Folia rubra, glabra, petiolata, petiolo 4–6 mm. longo, oblanceolata vel obovata, 3.5–6.5 cm. longa, 1.5–3 cm. lata, apice emarginata, late obtusa vel rotundata, basi cuneata, obscure serrulata, revoluta, coriacea, venis supra impressis. Pedicelli 2.3–3.5 cm. longi. Sepala late ovata, 6.5–8 mm. longa.

A tree 10 to 12 m. high, 30 cm. in diam.; branchlets stout, rather short, with leaves usually crowded at apex. Leaves red, glabrous, alternate, petiolate, the petioles stout, 4 to 6 mm. long, the blades oblanceolate or obovate, 3.5 to 6.5 cm. long, 1.5 to 3 cm. wide, apex emarginate, bluntly obtuse or rounded, base cuneate, very obscurely serrulate, revolute, rigidly coriaceous, lateral veins obscure below, the costa, veins and veinlets conspicuously im-

pressed above. Pedicels 2.3 to 3.5 cm. long, enlarged below the calyx, tapering to a slender base. Bractlets inserted at base of calyx, triangular, about 3 mm. long, deciduous. Sepals broadly ovate, 6.5 to 8 mm. long, margin of outer ones glandular-denticulate. Young fruits acute.

Type in the Herbarium of the University of Michigan, *Eizi Matuda 2814*, collected at Chiquihuite, Mt. Tacana, Chiapas, Mexico, March 27, 1939; alt. 2800 m.

*T. impressa* is noteworthy for the small thick rigidly coriaceous red leaves with veins prominently impressed above.

**Styrax magnus** sp. nov.—Arbor magna, 15–17 m. alta, 50–55 cm. diam. Ramuli ferrugineo-stellato-tomentosi. Folia alterna, petiolata, petiolo 1.4–2.8 cm. longo, chartacea, obovata vel elliptica, 12–20 cm. longa, 7–11.5 cm. lata, apice breviter acuminata, basi acutiuscula, supra nervis venisque stellato-pilosis, impressis, subtus albido-stellato-tomentosa, nervis lateralibus 10–12. Inflorescentiae axillares vel terminales, paniculatae, usque ad 10 cm. longae, ferrugineo-tomentosae. Pedicelli usque ad 12 mm. longi. Calyx ca. 3.5 mm. altus, tomentosus, quinquedentatus. Corolla 16 mm. longa, extus sericea, lobis valvatis, oblongis, ca. 11 mm. longis, 4 mm. latis. Stamina 10. Filamenta stellato-pilosa. Ovarium multiovulatum. Fructus ellipsoideus, ca. 18 mm. longus, 12 mm. diam.

A tree 15 to 17 m. high, 50 to 55 cm. in diam.; branchlets stout, ferruginous-tomentose with stellate hairs. Leaves alternate, the petioles stout, tomentose, 1.4 to 2.8 cm. long, the blades chartaceous, obovate or elliptic, 12 to 20 cm. long, 7 to 11.5 cm. wide, apex abruptly short acuminate to rounded, base slightly narrowed, acutish, subentire, persistently stellate-pilose above along the impressed costa and main lateral veins, glabrescent otherwise, under surface white tomentose with minute close indument and a coarser thinner stellate-pilose layer, main lateral veins 10 to 12 on each side, prominulous beneath, veinlets reticulate. Inflorescence axillary or terminal, paniculate, many-flowered, pedunculate, up to 10 cm. long, ferruginous-tomentose with stellate hairs. Pedicels up to 12 mm. long. Calyx white tomentose and bearing a few coarser rusty stellate hairs, cupuliform, about 3.5 mm. long, minutely 5-denticulate. Corolla about 16 mm. long, sericeous outside, the tube 4 to 5 mm. long, the lobes valvate, oblong, about 11 mm. long, 4 mm. wide, acutish, short pilose at apex. Stamens 10, shorter than corolla, the filaments stellate-pilose. Ovary stellate-pilose, 3-celled, ovules numerous. Style slender, about 11 mm. long, glabrous. Fruits ellipsoid, about 18 mm. long, 12 mm. in diam.

Type in the Herbarium of the University of Michigan, *Eizi Matuda 2982*, collected on north side of Mt. Tacana, Chiapas, Mexico, Apr. 2, 1939; alt. 2100 m.

*S. magnus* is referable to the section Eustyrax, series Valvatae in Perkins' monograph in the Pflanzenreich. Evidently it has affinity with *S. argenteus* from which it may be readily distinguished by the larger obovate or elliptic leaves, paniculate inflorescence up to 10 cm. long, differences in the corolla, and larger fruits.

**Symplocos tacanensis** sp. nov.—Arbor 8–10 m. alta, 30 cm. diam.; ramulis crassiusculis, hirsutis. Folia chartacea, flavescentia, oblonga vel oblongo-elliptica, 5–12 cm. longa, 2.5–5 cm. lata, apice abrupte acuminata, basi subcordata vel rotundata, subtus parce rufo-pilosa, minute denticulata. Petioli 4–8 mm. longi. Flores rosei in fasciculis sessilibus vel subsessilibus. Calycis tubus ca. 2 mm. longus, strigosus, lobis 5, ovatis, 3–3.5 mm. longis, strigosis, ciliatis. Corolla 13–14 mm. longa, lobis ciliolatis. Ovarium 3– vel 4–loculare, pilosum; stylus pilosus, 10–10.5 mm. longus. Fructus ellipsoideus, 17–20 mm. longus, 12–13 mm. diam., parce hirsutus.

A tree 8 to 10 m. high, 35 cm. diam. Branchlets rather stout, densely hirsute, the hairs reddish-brown. Leaves chartaceous, yellowish, oblong or oblong-elliptic, 5 to 12 cm. long, 2.5 to 5 cm. wide, apex abruptly short acuminate, base subcordate or rounded; appressed rufous-hairy above at first, glabrous with age; under surface persistently rufous-pilose, densely so along the prominent midrib; costa, veins, and veinlets impressed above, the main lateral veins 6 to 9 on each side, prominulous below, openly reticulate; margin obscurely and rather remotely denticulate with minute red subappressed glandular teeth. Petioles sulcate, hirsute, 4 to 8 mm. long. Flowers sessile, borne in dense sessile or subsessile hirsute fascicles at leafless nodes. Bracts ovate, rufous-brown, strigose. Calyx rufous-brown, strigose, the tube about 2 mm. long; the lobes 5, ovate, 3 to 3.5 mm. long, strigose and ciliate. Corolla 13 to 14 mm. long, the lobes adherent to stamen tube, connate below, obovate-oblong, rounded, ciliolate above the middle, each lobe with a small sericeous area below apex, the corolla entirely glabrous otherwise. Stamens slightly shorter than corolla, apparently in 5 series, glabrous, filaments united into a tube, free and complanate above. Ovary 3– or 4–celled, densely pilose; style 10 to 10.5 mm. long, densely pilose below, nearly glabrous above. Fruits ellipsoid, 17 to 20 mm. long, 12 to 13 mm. in diam., sparsely hirsute.

Type in the Herbarium of the University of Michigan, *Eizi Matuda 2976*, collected on north side of Mt. Tacana, Chiapas, Mexico, April 2, 1939; alt. 2100 m.

*S. tacanensis*, referable to Brand's subgenus Eusymplocos, section Symplocastrum, apparently belongs to the subsection Pseudalstonia in which it has affinity with *S. pycnantha* Hemsl. and *S. prionophylla* Hemsl. The copious rufous-brown coarse pubescence and the yellowish leaves immediately distinguish it from both of these.

**Bouvardia venosissima** sp. nov.—Ramuli graciles. Stipulae subulatae, 2–5.5 mm. longae. Folia opposita, subsessilia, membranacea, ovata vel ovato-lanceolata, 2.5–10 cm. longa, 1.7–5.5 cm. lata, apice attenuato-acuminata, basi subcordata vel rotundata, ciliata, striolata, prominente reticulata, venosissima. Inflorescentiae glabrae, axillares vel terminales, cymoso-corymbosae. Pedicelli 3–5 mm. longi. Calyx 4–lobatus, lobis subulatis, 1.8–2.6 mm. longis, apice ciliatis. Corolla rubra, striolata, extus glabra, intus ad basin villosa, tubo 9–11 mm. longo, lobis ovatis, ca. 3.5 mm. longis. Stamina inclusa. Capsula ca. 5 mm. diam., striolata.

Branchlets slender, striolate, at first somewhat compressed and conspicuously bisulcate with a few hairs scattered along the margins of the grooves, glabrous and terete with age. Stipules at first sparsely pilose at base, soon glabrous, subulate, 2 to 5.5 mm. long, short-laciniate. Leaves opposite, subsessile, the petiole up to 1.5 mm. long, the blades membranaceous, ovate or ovate-lanceolate, 2.5 to 10 cm. long, 1.7 to 5.5 cm. wide, apex attenuate-acuminate, base subcordate or rounded, ciliate, glabrous otherwise, striolate, conspicuously reticulate-veined on both surfaces, main lateral veins 4 to 6 on each side, pinnate, strongly arcuately ascending, anastomosing, the costa and veins slightly impressed above. Inflorescence glabrous, axillary and terminal, cymose-corymbose, usually many-flowered. Pedicels slender, 3 to 5 mm. long, becoming 7 mm. long in fruit. Hypanthium glabrous, about 1 mm. long. Calyx lobes subulate, 1.8 to 2.6 mm. long, usually ciliate at apex, glabrous otherwise. Corolla reddish, glabrous outside, striolate, the tube 9 to 11 mm. long, with a villous ring within near the base, the lobes ovate, about 3.5 mm. long. Anthers included, 2.5 to 3 mm. long. Style included or shortly exserted. Capsule about 5 mm. wide, striolate.

Type in the Herbarium of the University of Michigan, *Eizi Matuda 2748*, collected along border of Guatemala on Mt. Tacana, Chiapas, Mexico, Mar. 17–23, 1939; alt. 1400 m.

Additional specimens examined: MEXICO: Chiapas, Mt. Tacana, Aug., 1938, alt. 1000–2000 m., *Matuda 2464;* on north side of Mt. Tacana, April 2, 1939, alt. 2100 m., *Matuda 2954*.

*B. venosissima* has affinity with *B. dictyoneura* Standl., but differs, according to description, in its larger ciliate subcordate leaves and shorter calyx lobes ciliate at apex. All parts of the plant are minutely striolate, a noteworthy peculiarity. *Matuda S–157* and *860* from Mt. Ovando, Chiapas have been identified by Dr. P. C. Standley as *B. dictyoneura*, and I have interpreted this species on the basis of these collections. The Matuda material of *B. dictyoneura* does not have reticulate-veined leaves, a characteristic of this species according to the original description.

**Rondeletia tacanensis** sp. nov.—Frutex. Ramuli crassiusculi, pubescentes. Stipulae triangulares, 5–9 mm. longae, cuspidatae. Folia elliptica, 11.5–22 cm. longa, 7–11.5 cm. lata, apice acuminata, basi late cuneata, subtus novellis tomentosa. Petioli 1–3 cm. longi. Inflorescentiae terminales, pedunculatae, thyrsiformes, paniculatae, usque ad 30 cm. longae. Calyx 4–lobatus, lobis 3.2–7 mm. longis. Corollae tubus 17–18 mm. longus; lobi oblongi vel ovato-oblongi, 3.5–5 mm. longi, extus basi strigosi, intus glabri.

A shrub 3 to 4 m. high, 10 to 15 cm. in diam.; branchlets rather stout, subangulate, densely short hairy. Stipules triangular, 5 to 9 mm. long, rather abruptly cuspidate, erect, persistent. Leaves opposite, the petioles 1 to 3 cm. long, the blades elliptic, widest above the middle, 11.5 to 22 cm. long, 7 to 11.5 cm. wide, apex abruptly acuminate, base broadly cuneate, at first densely tomentose on under surface, with age sparsely so, the costa persistently hairy, upper surface bearing a few persistent hairs, main lateral veins 12 to 14 on each side, prominulous beneath, arcuately ascending. Inflorescence terminal, pedunculate, the flowers sessile in small crowded cymules, these sessile or pedunculate, arranged in narrow thyrsiform panicle up to 30 cm. long. Bracts subulate, 5 to 7 mm. long. Hypanthium densely pubescent with ascending subappressed short hairs, 2.5 to 2.9 mm. long. Calyx lobes 4, subulate, unequal, 3.2 to 7 mm. long, suberect. Corolla tube slender, 17 to 18 mm. long, nearly glabrous, bearing only a few hairs, these mostly at apex, naked in the throat, pilose at base within, the 4 lobes oblong or ovate-oblong, 3.5 to 5 mm. long, up to 4 mm. wide, spreading, undulate, glabrous within, strigose outside below. Apex of anthers exserted. Style included.

Type in the Herbarium of the University of Michigan, *Eizi Matuda 2928*, collected on west side of Mt. Tacana, Chiapas, Mexico, Mar. 30, 1939; alt. 2800 m.

Another collection from the same locality, *Matuda 2396*, is tentatively referred here. The leaves are pilose with spreading hairs on lower surface rather than tomentose, the branchlets and rachis of the infructescence are densely short hirsute, the panicle is as much as 45 cm. long, and the capsules are hairy, about 6.5 mm. long. This may represent a variety.

*R. tacanensis* belongs to the section Laniflorae (N. Amer. Fl. 32: 45. 1918), but does not appear close to any of the described species. The large leaves and very long panicles crowded with flowers are noteworthy.

**Viburnum chiapense** sp. nov.—Arbor 7 m. alta, 15–20 cm. diam. Ramuli crassiusculi, dense tomentosi, pilis stellatis flavescentibus. Folia ovata vel ovato-elliptica, usque ad 16.5 cm. longa, 11 cm. lata, apice acuminata, basi late rotundata et emarginata, dentata, supra parce stellato-pilosa, subtus stellato-tomentosa. Petioli usque ad 2.5 cm. longi. Pedunculi dense tomentosi, 6–7.5 cm.

longi. Cymae radii stellato-tomentosae. Calycis tubus stellato-tomentosus, usque ad 3 mm. longus, lobis ca. 1 mm. longis. Corolla campanulata, 4–5 mm. longa, extus parce strigosa. Stylus glaber.

A tree 7 m. high, 15 to 20 cm. in diam.; branchlets rather stout, terete, tawny, densely tomentose with fine stellate hairs. Leaves opposite, petiolate, the petiole up to 2.5 cm. long, densely stellate-pubescent; blades ovate or ovate-elliptic, up to 16.5 cm. long and 11 cm. wide, apex acuminate, base broadly rounded and emarginate, conspicuously dentate above the middle, the teeth gland-tipped, thinly stellate-pubescent above with sessile hairs, paler beneath, finely stellate-tomentose, the hairs substipitate or sessile, primary veins 5 or 6, strongly ascending, conspicuous on under surface. Peduncle 6 to 7.5 cm. long, tomentose like branchlets. Bracts at base of inflorescence linear, short. Cyme large, up to 11 cm. wide, 6.5 cm. long, usually 4 times compound, the primary rays 5 or 6, up to 3.5 cm. long, tomentose, secondary rays up to 1.7 cm. long. Bractlets at base of flowers linear, stellate-pubescent. Flowers sessile. Calyx tube up to 3 mm. long, stellate-tomentose, the lobes usually triangular, about 1 mm. long, stellate-pubescent. Corolla campanulate, 4 to 5 mm. long, lobed to the middle, sparsely short strigose externally with straight simple hairs. Filaments about 3 mm. long. Style glabrous. Dry fruit ovoid, about 6.5 mm. long, about 5 mm. in diam., sparsely stellate-pubescent, not conspicuously grooved, the intrusion pronounced, extending almost to the center.

Type in the Herbarium of the University of Michigan, *Eizi Matuda 2925*, collected on west side of Mt. Tacana, Chiapas, Mexico, Mar. 30, 1939; alt. 2800 m.

*V. chiapense*, referable to the section Disjuncta of Morton (Contr. U. S. Nat. Herb. 26: 342. 1933), is related to *V. disjunctum* Morton and *V. jucundum* Morton. From *V. disjunctum*, *V. chiapense* may be separated by its ovate conspicuously dentate leaves, calyx tube almost three times as long, calyx lobes twice as long, and much larger corolla. *V. jucundum* bears a close resemblance, but differs at once in its stellate-pubescent smaller corolla, short peduncle, and less conspicuously toothed smaller leaves.

University of Michigan

# Some Incorrectly Described Asclepiads

ROLAND M. HARPER

(WITH TWO FIGURES)

Many or most of the plant descriptions in our manuals seem to have been written by persons who either have never seen the species growing, or else have collected them on hurried trips, along with many other plants, without taking time to study them until after they were pressed. In this way important characteristics of the living plants that are obscured by the drying and pressing process are often overlooked; and this is especially true of fruits and seeds, which are collected less frequently than flowers.[1]

An interesting case of this is the southern swamp milkweed, *Asclepias perennis*. That species was described by Thomas Walter in his Flora Caroliniana in 1788, and later named *A. parviflora* by Aiton (who perhaps was unaware at the time of Walter's description) in 1789, and *A. debilis* by Michaux in 1803. Its present known range is in alluvial swamps from Georgia (and perhaps South Carolina) to Louisiana (and perhaps Texas) in the coastal plain, and inland in the Mississippi valley to the Wabash bottoms of Indiana. Although apparently all our Asclepiadaceae are perennials, the name Walter selected for this species was probably suggested by the fact that its stem generally has one or two stubs of dead trunks near the base, presumably indicating that it does not die down completely to the ground in winter, and puts out a new stem from a little above the ground in spring. The stem is rather tough, and although it would hardly be called woody, the plant might be classed as a short-lived shrub.

There is quite a long description of it in Elliott's Botany of South Carolina and Georgia 1: 323–324. 1817), under the name of *A. parviflora* (with *A. perennis* and *A. debilis* given as synonyms); but Elliott, like his predecessors, said nothing about its fruit or seeds.

The next important treatment is that of Chapman (Fl. So. U. S., 365. 1860), who used Walter's name, *perennis*, and gave *parviflora* and *debilis* as synonyms. He made it the last species in the genus, and distinguished

[1] For an illustration of an important fruit character that is wholly obscured in dried specimens see my note on *Kneiffia*, in the Plant World, 8: 301–303. "Dec. 1905." [Jan. 1906.] The character there described furnishes an additional means of separating *Kneiffia* from *Oenothera*, which was disregarded by Munz in his revision of *Kneiffia* a few years ago (Bull. Torrey Bot. Club 64: 287–306. 1937). *Kneiffia* had long been known to differ from *Oenothera* in having its flowers open all day, instead of at night, but in spite of that some member of the Plant World editorial staff, thinking only of *Oenothera*, attempted to make my article more "popular" by inserting the inapplicable common name "evening primrose" without my knowledge or consent.

from the 18 others, in his key, by the words "Stem shrubby: seeds mostly naked." In the description the only statement about the fruit is "follicle ovate-lanceolate, smooth;" and there is no further mention of the seeds.

The next edition of Gray's Manual after that, the fourth, dated 1863, calls our plant *A. parviflora* again, and says "Coma of the seeds wanting;" and that was repeated in various later editions.

Britton and Brown's Illustrated Flora (3: 12. 1898) describes it as *A. perennis* Walt. (with no synonyms), allies it most closely with *A. brachystephana* Engelm., a Great Plains species, and says of it in part: "follicles glabrous, erect on the erect fruiting pedicels; seeds . . . . very thin, destitute of coma." This seems to be the beginning of a misstatement about the fruit that has been current ever since; but the description of the seeds is correct enough.

Small, in his Flora of the Southeastern United States, 1903, recognized 30 species of *Asclepias*, and put *A. perennis* near the middle of the genus, between *A. Curassavica* and *A. Texensis*, in a group of 12 species characterized by "follicles erect on erect fruiting pedicels." In his key one of the distinguishing characteristics for this species was "seeds destitute of coma" (a fact not easily ascertained at flowering time). In the description the statement about follicles was repeated from the key, but the seeds were said to be "1–1.5 mm. long . . . . apparently destitute of coma." (The "mm." was evidently a misprint for cm.)

In his Manual of the Southeastern Flora, thirty years later, *A. perennis* is put with *A. incarnata* and *A. pulchra* (two northern bog or marsh species which were formerly regarded as only varietally distinct from each other, and which I have never seen in the South) in the section *Incarnatae;* and that and two other sections are characterized in the key by "follicles erect on erect pedicels." In neither key nor description is there any mention of whether the seeds are comose or not (as if he was not sure about that), but the length of the seed is given as 9–12 mm. (In only one other of the 24 species of *Asclepias* recognized in that book is the size of the seeds mentioned, and that is *A. quadrifolia*, the next species, with seeds 5–6 mm. long.)

In Robinson and Fernald's Manual (the so-called 7th edition of Gray's) for the northeastern states (1908), *Asclepias perennis* is one of four species characterized in the key by "follicles and pedicels erect." In the description (p. 656) there is no further mention of the fruit, but the seeds are said to be "sometimes destitute of a coma!" (The exclamation point is part of the quotation.)

Prof. Fernald writes me that the several ambiguous statements about the seeds, that I have quoted, may be based on *Asclepias texana* Heller, which was described by Gray in 1876 as *A. perennis* var. *parvula* (raised to a species by Miss Vail in 1899), and was regarded by his suc-

Fig. 1. Goose Pond, a tupelo gum slough in bottoms of Warrier River about six miles west-southwest of Tuscaloosa. July 30, 1938. No specimens of *Asclepias perennis* appear in the view, but it was collected in a similar place in the same slough a few weeks later, when the water had receded.

cessors as doubtfully distinct, though accepted as a good species by Small in 1903. That species seems to be known only from a few old specimens from Texas, and is said to resemble *A. perennis* in having a stem woody at the base, and rather large reddish seeds, but the follicles are apparently erect, and the seeds comose as in most other species of the genus. It very likely grows in open places, where the seeds are readily transported by the wind (as in the Asclepiadaceae generally), while *A. perennis* frequents dense shady swamps.

Herbarium specimens of any or all species of *Asclepias* usually represent the flowering stage only, for the flowers are rather showy, and differ perceptibly in every species. And as botanists are not very numerous within the range of *A. perennis*, it is not surprising that its fruiting stage

Fig. 2. Some typical fruiting specimens of *Asclepias perennis*, collected in and around Goose Pond, Sept. 7, 1938, and photographed in the office a few hours later, before pressing. Some loose seeds are also shown. The scale indicates inches.

should have been so long misunderstood. I have known the species since 1901, but never saw its fruit until June 28, 1933, and only one or two follicles then, in the bottoms of the Warrior River in Tuscaloosa County, Alabama. That was a little early for fruit, but one of the specimens collected at that time (no. 3079) shows a follicle nearly grown. I noticed

then that the follicles are by no means erect on erect pedicels, as the books indicated, but hang down below the leaves on slender recurved pedicels. In the summer of 1938, in the same neighborhood, I looked into the matter further, collected some more specimens, also examined the seeds for the first time.

I found the seeds to be about 10–12 mm. long and nearly as wide, broadly winged, chestnut-colored, and entirely devoid of the long apical hairs which in other species of *Asclepias* function like a parachute for dispersal by wind. And instead of lying parallel to the walls of the pod, hanging downward from its apex (which is uppermost in most species), and overlapping like shingles, as in all the well-known species of the genus, they were attached to a narrow longitudinal placenta by one end, and lay almost at right angles to the length of the pod, closely piled like a stack of coins.

The specimens illustrated herewith were collected on Sept. 7, 1938 (no. 3697) in and around a tupelo gum (*Nyssa uniflora*) slough (called "Goose Pond" on the recent government topographic maps) in the alluvial bottoms of the Warrior River, about six miles west-southwest of Tuscaloosa. On account of the dense shade and lack of a contrasting background it was impractical to photograph them on the spot, but they were photographed in my office a few hours later, before the leaves had wilted perceptibly, and then pressed.

A skeptic inclined to accept as gospel the statements in the books about "follicles erect on erect pedicels" might imagine that the pedicels in the specimens photographed had drooped with partial wilting, or been bent down purposely. But it should be evident enough from the photograph that the pedicels are too long and slender to hold a fruit of that size erect.[2] At the time of collection some of the follicles were still green and unopened, and some in various stages of dehiscence. Some of the ripe seeds were scattered beside the plants when photographed, to show their size, which is probably the largest in the genus.

The other illustration shows the vegetation in Goose Pond, with *Nyssa uniflora* predominating, as it appeared on July 30, when the water may have been two feet deep in the center. The *Asclepias* did not grow in the deepest parts, but chiefly about where the edge of the water was at that time, and also a little farther away. At the time the specimens were

[2] I have not had access to a large herbarium recently, but Charles C. Deam of Bluffton, Ind., the best living authority on Indiana plants, showed me a fruiting specimen of *A. perennis* from the Wabash bottoms of southwestern Indiana when I visited him in the fall of 1938, and a few days later he got another for me from the same neighborhood; and these plants are scarcely distinguishable from my Alabama specimens.

collected, nearly six weeks later, the water had practically disappeared, but the middle of the slough was still pretty muddy.

Throughout the range of *Asclepias perennis* the streams are generally highest in winter and spring, when the plants are dormant. When they bloom in summer the water is usually receding, and probably in most years when the seeds are ripe the ground under the plants is bare. If such a plant grew on a prairie and held its follicles erect the broadly winged seeds might be carried a few yards by the wind, but there can be little wind in the depth of the swamps, and (figuratively speaking) the plant evidently does not count on any such assistance. So it hangs its follicles down, and when the seeds are discharged they must fall to the ground, to lie until the winter and spring rains raise the water again and float them away.

It has been said by some good authority[3] that different modes of dissemination seldom occur in the same genus. I am not at present proposing to establish a new genus for *Asclepias perennis* on account of its seed without coma (and a few other peculiarities that have been mentioned), but it would seem to deserve that status better than some other recent segregations from the genus, and it should probably be set off in a section by itself, as Chapman had it, instead of being grouped with species that are very unlike it. But we need to know more about the little-known *A. texana*, which may be a connecting link.

In mode of dissemination there is an interesting analogy between *Asclepias perennis* and *Quercus lyrata* (also first described by Walter), which has a similar range and habitat, and can often be found in close proximity to the *Asclepias*. The acorns of that oak have a corky layer around the seed, which together with the enclosing cup enables them to float; and that species may be the only oak in the world with floating acorns.[4]

A character that applies to the whole genus *Asclepias*, and some if not most of the other genera in the same family, but is seldom if ever mentioned in the books, should be noted here. In the whole family, as in the allied Apocynaceae, the gynoecium consists of two carpels. In the Apocynaceae both carpels usually develop, into a pair of slender follicles, but in *Asclepias* it is very exceptional for more than one from a single flower to mature. Not only that, but of all the numerous flowers in each umbel, all apparently perfect and with equal opportunities for pollination, it is

[3] I do not now recall where I first read this, but I referred to it in Torreya 8: 159, 160. 1908.

[4] I discussed this at the St. Louis meetings of the Ecological Society of America in December, 1935, and exhibited there cross-sections and photographs of the acorns, but have published nothing on it as yet but a brief note in the program for that meeting.

unusual for more than one to produce any fruit; just as if in a large family only one of the children married.

When the seed of any of the common species of *Asclepias* goes floating off through the air, the silky hairs that form a tuft at its apex look very much like the pappus on the achenes of many Compositae, which is a modified calyx-limb. But the coma in *Asclepias* is of course very different morphologically. These hairs are not mere trichomes either; for in the ovary they are the means of attachment of the seed to the placenta, and the pollen tubes must find their way to the ovules through them; a fact not mentioned in any description that I have seen.

The fruits of some other genera of Asclepiadaceae have been inadequately described, probably for the same reason as in *Asclepias perennis*, namely, they are seldom collected.

In 1818 Thomas Nuttall described the genus *Enslenia*, with a single species, *E. albida*, a twining vine growing on river banks in Virginia and Ohio. Although it is now known as far south as Georgia, if not Florida, Elliott was not acquainted with it, and it is not mentioned in the first edition of Chapman's Southern Flora, 1860. Chapman described it in the supplement which was added to the first edition to make the second edition, in 1883, and said of the fruit only "follicle fusiform."

Britton in 1894[5] discovered that Nuttall's *Enslenia* was antedated by an *Enslenia* of Rafinesque, 1817, but found another generic name of Rafinesque's, *Ampelamus*, that applied to our vine, and transferred the species to that. As *Ampelanus albidus* it is described and figured in the first edition of Britton and Brown's Illustrated Flora (3: 16. 1898). The illustration shows a smooth follicle with the apex upward, and the description says "follicles erect on the ascending fruiting pedicels, 4′–6′ [inches] long, glabrous when mature."

The following year Miss Anna M. Vail,[6] after a study of type specimens in Paris, announced that Michaux's *Gonolobus laevis* (1803), from Illinois, was the same as Nuttall's *Enslenia albida;* and accordingly Michaux's name, which was 15 years older than Nuttall's, has been used by subsequent American writers. She mentioned that the follicles in the type specimens were angled; and that was accepted as typical of *Enslenia* (*Ampelanus*) by Small, who in his description of "*Gonolobus laevis*" (Fl. S.E. U.S., 951–952) in 1903 said: "follicles erect on spreading pedicels, 10–15 cm. long, glabrous, wing-angled." Robinson and Fernald in 1908 said of the same plant: "follicles elongate-ovoid to lanceolate,

[5] Bull. Torrey Bot. Club 21: 314. 1894.
[6] Bull. Torrey Bot. Club 26: 427. 1899.

smooth," but nothing about angles—except inferentially in translating the generic name *Gonolobus*—or about the size or position of the fruit. Small's Manual, 1933, repeats the statement "follicles wing-angled," but his illustration shows no wings.

Miss Lily M. Perry has recently thrown a little new light on the subject.[7] Miss Vail in her study of 1899 noted that the supposed type of Michaux's *Gonolobus laevis* consisted mostly of numerous small pieces, "but all of the specimens in the two collections agree and point unmistakably to the plant since called *Enslenia albida* Nutt." A little farther on, however, she admitted the presence of a fragment of *Gonolobus suberosus* (*Vincetoxicum suberosum* (L.) Britton) on one of the sheets. Miss Perry pointed out that the flowers of the type specimen do not agree at all with Michaux's generic description of *Gonolobus*, and that Dr. Gray had interpreted it quite differently from Miss Vail. But she made no special comment on the fruit, apparently being willing to let that go as representing *Enslenia*.

Dr. Charles Mohr, reporting on this species in his Plant Life of Alabama,[8] knew it only from a specimen collected in Jackson County, in the Tennessee Valley, by some anonymous collector for the Biltmore Herbarium. But in the fall of 1908, having previously become acquainted with it in Georgia, I saw what I took to be it at a few places along the Tombigbee River in southern Alabama. I noted then that, contrary to current descriptions, the juice of the plant was not milky, and its follicles were neither angled nor erect; and on account of these discrepancies I was not sure that I had identified it correctly.[9]

I did not see the fruit of *Enslenia* ("*Gonolobus*") again until September, 1938, when I found the vine climbing over a hedge in the yard of a friend in the outskirts of Lexington, Kentucky. There I verified my observation of nearly thirty years before, that the pods were not at all angled (though a little wrinkled longitudinally), and they hung down, as such heavy objects would necessarily have to do on a slender herbaceous vine, no matter how stout their pedicels. An exception to this, however, was afforded in occasional instances where both follicles from the same flower developed. In such cases they diverged at an angle of 180,° and would probably have been horizontal if one had not been a little larger than the other, upsetting the balance.

[7] Rhodora 40: 281–283. 1938.
[8] Contr. U. S. Nat. Herb. 6: 677. 1901.
[9] Bull. Torrey Bot. Club 37: 115. 1910.

It would appear from the writings of Miss Vail and Miss Perry, already cited, that the specimens labeled *Gonolobus laevis* by Michaux include flowers of *Enslenia* (*Ampelamus*) and follicles of another twining genus of the same family, with very different flowers and fruit, which was described as *Vincetoxicum*[10] by Walter in 1788; and this has led several writers since Miss Vail to the belief that the follicles of *Enslenia* are angled. Of course it is barely possible that Michaux really had a species of *Enslenia* with angled follicles, different from the more southerly one; but his genus *Gonolobus* when published included two other species, which are considered typical *Vincetoxicums*, and the *Enslenia* flowers may have been mounted on the sheet of *G. laevis* by some careless person after his death, for he died before his Flora Boreali-Americana was published, and the work was completed by L. C. Richard. In any case, the name *Gonolobus*, which means angle-pod, cannot be considered as typified by the species under discussion, whose pods are not angled.

Although the usual habitat of our plant is river-banks, and it does not seem hitherto to have been charged with weedy tendencies, it was certainly a weed at the Kentucky station above mentioned, and many miles from any river. And in the last few years I have found it climbing on cultivated shrubs on the campus of the University of Alabama. That is about half a mile from the Warrior River, but I have not yet observed it along that river. I collected a flowering specimen (no. 3588) on the campus on July 22, 1937, but ever since I have known the station the vines have been torn out by gardeners before they had a chance to make fruit.

UNIVERSITY, ALABAMA

[10] The application of this name, which does not particularly concern us here, was discussed by Miss Perry in the paper cited. Several species with follicles muricate as in *Asclepias Syriaca*, instead of angled, were put in a separate genus, *Odontostephana*, by E. J. Alexander in Small's Manual, 1933, but those are put back in *Gonolobus* without explanation by Miss Perry.

# A New Species of Tetraëdron from Minnesota

CHARLES B. REIF

(WITH TEN FIGURES)

**Tetraëdron grande** sp. nov.

Cellulae singulae pelagicae 4–angulatae forma tetrahedrica ad unum planum angulis productis in spinas longas solidas pariete convexo 4$\mu$ crasso. Longitudo cum spinis 135$\mu$; latitudo cum spinis 87$\mu$.

Cells four angled, basic four-sided shape tending toward one plane with two sides, the angles produced into long, tapering, solid spines; these spines occasionally undulating at tip but never furcate or decorated; cells solitary free floating and pelagic; walls smooth, 4$\mu$ thick; wall bearing lateral spines more convex than wall of long axis.

This species is much larger than any heretofore described in the genus Tetraëdron. Measurements of forty individuals gave the following averages($\bar{x}$). The dimensions taken are indicated on figure ten and all are expressed in microns.

| *Dimension* | *A* | *B* | *C* | *D* | *Thickness* |
|---|---|---|---|---|---|
| $\bar{x}$ | 134.9 | 67.8 | 87.1 | 49.8 | 37.7 |
| $s_{\bar{x}}$ | 9.9 | 5.5 | 9.8 | 3.9 | 3.2 |

This species is placed in Section I, Polydrium (Naegeli) Hansgirg of the genus Tetraëdron. It is most closely related to *T. quadricuspidatum* (Reinsch) Hansgirg which approaches the new species both in size and form. The separation of the two species is made on the difference of twenty microns in size and the positions of the lateral spines. In *T. quadricuspidatum* the lateral spines tend to curve more toward one end, forming a trident shape, whereas in the new species the lateral spines are more independent and may even project almost at right angles to the long axis. Both of the above species are related to *T. regulare* Kützing. *T. tortum* West is nearly equal in size but there can be no confusion between its twisted shape and the graceful lines of the species here described.

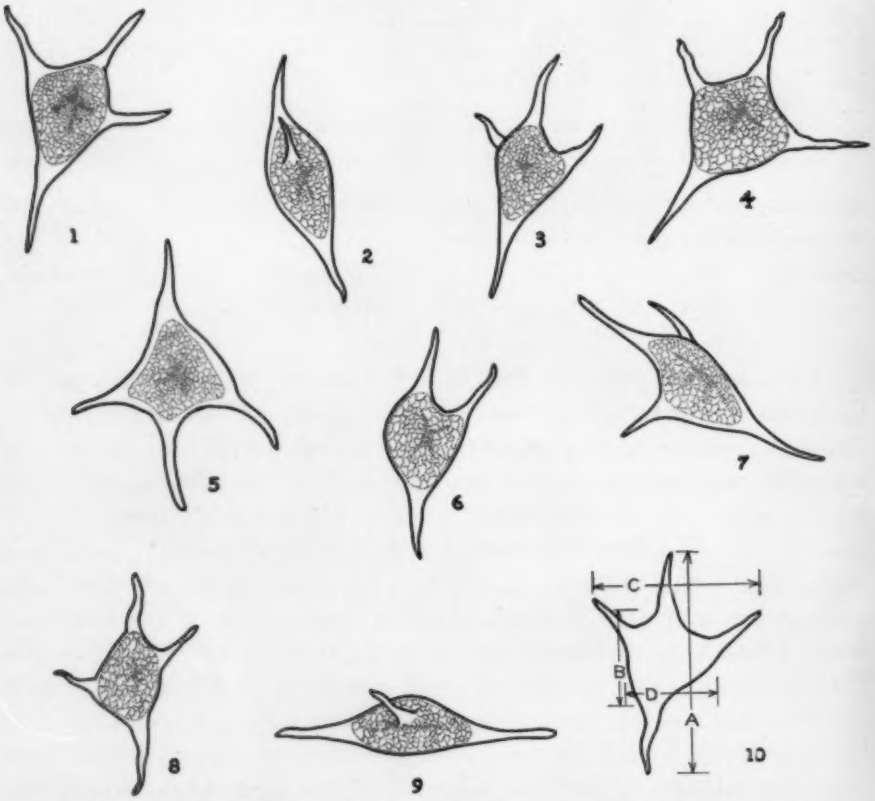
*Tetraëdron grande* has been found in four eutrophic lakes of west-central Minnesota. All of these lakes are of the same character and lake type as shown by the following physical data (Table 1) taken at the same time the plankton collections were made in which the alga appeared.

It will be noted that the records fall in the months of August and September. Samples taken from these lakes in June contained no individuals of this species. In all four lakes the most common plankter on the dates given above was *Ceratium hirundinella*. Another interesting

TABLE 1
*Physical Characteristics of Lakes*

| *Lake* | *Date* | *pH* | *—$HCO_3$* | *Tot. dis. solids* | *Temp.* |
|---|---|---|---|---|---|
| GILSTEAD | 8/22/36 | 8.2 | 160 ppm. | 250 ppm. | 70° F. |
| NORTH STAR | 8/10/36 | 8.4 | 102 ppm. | 173 ppm. | 72° F. |
| BALL CLUB | 9/ 2/36 | 8.2 | 131 ppm. | 124 ppm. | 65° F. |
| OTTERTAIL | 9/13/36 | 8.4 | 231 ppm. | 647 ppm. | 68° F. |

association which was present in all of the four cases cited was that of *Coelosphaerium Kützingianum, C. Naegelianum* and *Melosira granulata.* These three species were predominant in the order named.




Figs. 1–10. Various aspects of *Tetraëdron grande* sp. nov. × approx. 275.

Vertical samples indicated that in Gilstead lake *Tetraëdron grande* occurred slightly more abundantly at the four metre level than at the surface, although it was present at the eight and twelve metre levels as well. This has been shown to be a normal distribution for most Chlorophyceae.

UNIVERSITY OF MINNESOTA

# New and Unusual Species of Uredinales[1]

E. B. Mains

In this paper, data are presented concerning a number of species of rusts based on information obtained from collections which have been received from time to time from various sources. All specimens, including types, have been deposited in the Herbarium of the University of Michigan.

## Coleosporium Madiae Cooke

In 1937, a collection of a rust on *Argyroxiphium sandwicense* DC. was received from Willis W. Wagner of the Division of Forestry of the United States Department of Agriculture. The collection was made by Eric Walther in the rare plant garden of the Golden Gate Park, San Francisco, California. The host is a Hawaiian species for which no rust has been reported. The rust proves to be *Coleosporium Madiae* which occurs on various species of *Madia* on the Pacific coast of the United States. *Argyroxiphium* and *Madia* are closely related genera of the *Heliantheae* of the *Compositae*. If *Coleosporium Madiae* should be introduced into Hawaii it doubtless would become an important parasite of *Argyroxiphium*.

It is interesting to note that M. W. Gardner has recently reported *C. Madiae* on African Marigold at San Juan, California. The host, *Tagetes erecta*, is also an introduced species for which the rust had not been previously reported.

## Puccinia Ammophilina comb. nov.

*Uredo Ammophilina* Kleb. Krypt. Flora Mark Brandenburg 5A: 882. 1914.

Uredinia epiphyllous, between the veins, cinnamon-brown, ruptured epidermis evident; urediniospores broadly ellipsoid, 22–26×26–36μ, the wall yellowish or brownish 1.5–2.5μ, moderately echinulate, the pores 6–8 scattered; paraphyses variable in abundance, capitate, up to 60μ long, 6μ wide below, the head 12–20μ, the wall hyaline, 1μ.

Telia epiphyllous, between the veins, chestnut- to chocolate-brown, somewhat tardily naked, the ruptured epidermis evident; teliospores clavate to oblong-clavate, 16–22×38–62μ, the wall yellowish-brown below, chestnut-brown above, 1μ thick below, 4–5μ at the apex, the pedicel short, fragile.

On *Ammophila arenaria* (L.) Link, Lake Lytle, Oregon, Nov. 4, 1936 (Ore. no. 10–733); Lake Lytle, Oregon, March 8, 1938; Twin Rocks,

[1]Paper from the Department of Botany and the Herbarium of the University of Michigan.

Oregon, Sept. 24, 1937, R. Sprague; *A. breviligulata* Fernald, on sand dunes, AuTrain, Michigan, Aug. 24, 1932, E. B. Mains (32–285).

Rust on *Ammophila arenaria* and *A. breviligulata*, two very closely related species, has apparently not previously been reported from North America. In Europe, two species, *Uredo Ammophilae* Syd. and *U. Ammophilina* Kleb. have been known. *Uredo Ammophilae* is described as having urediniospores 21–26$\mu$ or 18–24 x 26–34$\mu$ with walls 2–3$\mu$ thick. It lacks paraphyses. *Uredo Ammophilina* differs in having capitate thin-walled paraphyses and urediniospores 21–26 x 27–39$\mu$ and walls 1.5$\mu$ thick. The North American collections agree well with the latter. The occurrence of teliospores in the Oregon collections received from R. Sprague makes it possible to place this species in Puccinia.

### Puccinia amphigena Diet.

A collection of rust on *Ammophila breviligulata* Fernald, made by G. W. Martin (1650) at Mineral Springs, Indiana, Sept. 23, 1931, was received from G. B. Cummins. This has abundant amphigenous telia, containing some urediniospores. The collection appears to be *Puccinia amphigena* which has previously been reported only on species of *Calamovilfa*. A comparison of the descriptions of the uredinia of *P. amphigena* and *Uredo Ammophilae* shows a very close similarity and suggests that they may be the same species. Opposing this is the scanty and amphigenous development of uredinia of *P. amphigena* and the abundant epiphyllous development of uredinia of *U. Ammophilae*.

### **Frommea mexicana** sp. nov.

Urediniis hyophyllis, sparsis, mox nudis, pulverulentis, pallide flavis; urediniosporis ellipsoideis vel obovoideis, 13–16$\times$16–20$\mu$, membranis tenuissimis, 0.5$\mu$, hyalinis, echinulatis, poris inconspicuis; teliis hypophyllis, sparsis, subpulverulentis, cinnamoneo-brunneis; teliosporis cylindriceo-clavatis, 23–32$\times$38–60$\mu$, apice rotundatis, basi rotundatis vel vix attenuatis, 2–3-septatis, membranis 1.5–2$\mu$ crassis, apice 4–6$\mu$, pedicellis usque 50$\mu$ longis, hyalinis.—*Fragaria mexicana* Cham. and Schlect. Chapulhuacan, Hidalgo, Mexico VII. 12, 1937, C. L. et Amelia Lundell (7182, specimen typicum).

The Sydows (Monograph. Ured. 3: 102. 1915) doubtfully list *Fragaria vesca* as a host of *Phragmidium Fragariastri* in Europe. Otherwise this is apparently the first record of a rust on a strawberry. *Duchesnea indica*, the host of *Frommea Duchesneae* at one time was placed in Fragaria but is now generally recognized as generically distinct. It

supposedly was introduced from Asia yet the rust is known only from North America. This suggests that the rust originally occurred on an indigenous host and Fragaria would be a logical source. Opposing this, however, is the absence of rust on Fragaria in the area where *Frommea Duchesneae* occurs.

The species of *Frommea* are very closely related. *Frommea obtusa* (Str.) Arth. is widely distributed in the temperate portions of the northern hemisphere on species of *Potentilla*. *Frommea Duchesneae* Arth. occurs in the southeastern United States on *Duchesnea indica*. The teliospores of *F. obtusa* are 2–6–septate and measure 20–27 x 40–90$\mu$ and the urediniospores are 15–20 x 19–26$\mu$ with walls 1.5–2$\mu$ thick. The teliospores of *F. Duchesneae* are 2–4–septate and measure 19–26 x 50–80$\mu$ and the urediniospores are 12–17 x 15–21$\mu$ with walls 1$\mu$ thick.

### Puccinia cornuta Jacks. & Holw.

On *Notoptera scabridula* Blake, Cohune Ridge, El Cayo, British Honduras, July 11, 1936, E. B. Mains (3798). Only pycnia and aecia occur in this collection. It differs somewhat from the description of the species. The aecia are lighter in color and the aeciospores more irregular, often having 2 or 3 rather prominent projections. Arthur (Am. Jour. Bot. 5: 533. 1918) reported the species from Guatemala on *Notoptera brevipes* (Robinson) Blake.

### Puccinia Ichnanthi sp. nov.

Urediniis amphigenis, sparsis, cinnamoneis, 0.2–0.5 mm. dia.; urediniosporis late obovoideis vel ellipsoideis, 22–30×30–44$\mu$, membranis cinnamoneis, 1.5–2.0$\mu$ crassis, conspicue echinulatis, poris 2–3, aequatorialibus; teliis hypophyllis, pallide brunneis, 0.2–0.5 mm. dia.; teliosporis fusoideis, 12–14×28–34$\mu$, membranis hyalinis vel pallide brunneis, tenuissimis, 1$\mu$, pedicellis hyalinis, 12–30$\mu$ longis.—*Ichnanthus candicans*, (Nees) Doell, Tijuca, Dist. Federal, Brazil, IV. 28, 1930, Agnes Chase (12143A, specimen typicum).

This rust was obtained from a phanerogamic specimen in the Herbarium of the University of Michigan. The urediniospores are very similar to those of *Puccinia inclita* Arth. which has been reported on species of *Ichnanthus*. The teliospores are very different and unusual for a grass rust. They have colorless or brownish, very thin walls which are uniform in thickness. They germinate at once. In these characters the rust agrees with species which have been placed in the genus *Eriosporangium*. However, the species of *Eriosporangium*, for which the full life-cycle is known,

all have been autoecious and the aecia in most species have lacked perida. Most species of grass rusts have been heteroecious and the aecia have well developed peridia. Except for species of *Angiopsora* the grass rusts have been either species of *Puccinia* or *Uromyces* and it seems best for the present, at least, to place this species in *Puccinia*.

### Puccinia Nephrophyllidii sp. nov.

Urediniis amphigeniis, hypophyllis, sparsis, 0.2–0.5 mm. dia. tarde nudis, pulverulentis, cinnamoneo-brunneis; urediniosporis late ellipsoideis, 22–26×28–32$\mu$, membranis cinnamoneo-brunneis, 2–2.5$\mu$ crassis, moderate echinulatis, poris 1–3, semper fere 2, superaequatorialibus; teliis amphigenis, hypophyllis, sparsis, 0.5–0.8 mm. dia., tarde nudis, pulverulentis, atri-brunneis; teliosporis variabilis, irregulater oblongis, ellipsoideis vel clavatis, 20–32×36–68$\mu$, membranis castaneo-brunneis, 2–2.5$\mu$ crassis, ad apicem papillula 6–7$\mu$ alta, instructis, pedicellis hyalinis, brevis.—*Nephrophyllidium Crista-galli* (Meng.) Gilg, Ketchikan, Alaska, VIII. 3, 1938. D. V. Baxter.

The host belongs in the *Gentianaceae* and has been included by some botanists in the genus *Menyanthes*. Apparently no rust has previously been reported for either *Nephrophyllidium* or *Menyanthes* and the species is distinct from other rusts of the *Gentianaceae*.

### Puccinia ripulae nom. nov.

*Puccinia riparia* Mains, Papers Mich. Acad. Sci. Arts and Letters 22: 156–157. 1937. non *Puccinia riparia* Holway, Jour. Mycology 10: 163. 1904.

In 1937, a rust collected on *Baccharis glutinosa* at Alamo, Hidalgo Co., Texas by Elzada N. Clover (1130) was described and named *Puccinia riparia*. Dr. Grant D. Darker has called my attention to the fact that the name *P. riparia* was previously applied to a rust of Carex by Holway. Arthur (North Am. Flora 7: 355. 1920) has considered this a synonym of *Dicaeoma Grossulariae* (Schum.) Kern [= *Puccinia Caricis* (Schum.) Scroet.]. It is therefore necessary to give a new name to the rust of *Baccharis* and *Puccinia ripulae* is proposed.

### Pucciniastrum alaskanum sp. nov.

Urediniis hypophyllis, subepidermalibus, sparsis, 0.2–0.3 mm. dia. poro centrali apertis; peridiis hemisphaericis, ex cellulis minutis compositis; urediniosporis oblongis vel anguste ellipsoideis, 12–16×24–40$\mu$, membranis hyalinis, 1.5$\mu$ crassis, minute echinulatis, poris inconspicuis; teliis ignotis.—*Gentiana glauca* Pall., Mt. McKinley National Park, Alaska, VII. 19, 1933, D. V. Baxter.

Although telia have not been seen, the uredinia are characteristic for *Pucciniastrum*. *Pucciniastrum Gentianae* as described by Hiratsuka and Hashioka (Tottori Soc. Agr. Sci. 5: 237. 1935) from *Gentiana formosana* in Japan has shorter and broader urediniospores (17–23 x 21–27$\mu$) and thicker urediniospore-walls (2–3$\mu$).

### Uredo detenta sp. nov.

Urediniis hypophyllis, sparsis, 0.5 mm. longis; urediniosporis late ellipsoideis vel obovoideis, 20–28×28–36$\mu$, membranis atri-cinnamoneis, 2.5–4$\mu$ crassis, conspicue echinulatis, poris 3–4, equatorialibus.—*Olyra micrantha* H. B. K. Gavea, Estado do Rio de Janeiro, Brazil, Nov. 2, 1929, Agnes Chase (9981A, specimen typicum); Avenida Niemeya, Rio de Janeiro, Nov. 5, 1929, Agnes Chase.

This rust was obtained from phanerogamic specimens in the Herbarium of the University of Michigan. The urediniospores of this species are smaller than those of *Puccinia belizensis* Mains described (Contrib. Univ. Mich. Herb. no. 1, p. 8. 1939) from *Olyra latifolia* from British Honduras.

University Herbarium
University of Michigan
Ann Arbor, Michigan

# A New Species of Cuscuta from Yucatan

T. G. Yuncker

(WITH ONE FIGURE)

**Cuscuta palustris** sp. nov. Caules crassitudine modici usque tenues. Flores subcarnosi, 5– aut 4–divisi, circ. 2 mm. longi a basi ad corollae sinum. Pedicelli floribus, aequilongi vel breviores. Inflorescentia paniculato-cymosae. Calycis lobi ovato-lanceolati, acutissimi, ad basin plus minusve imbricati, sinibus obtusis. Corollae lobi acutissimi, ovato-lanceolati, tubo campanulato aequilongi vel

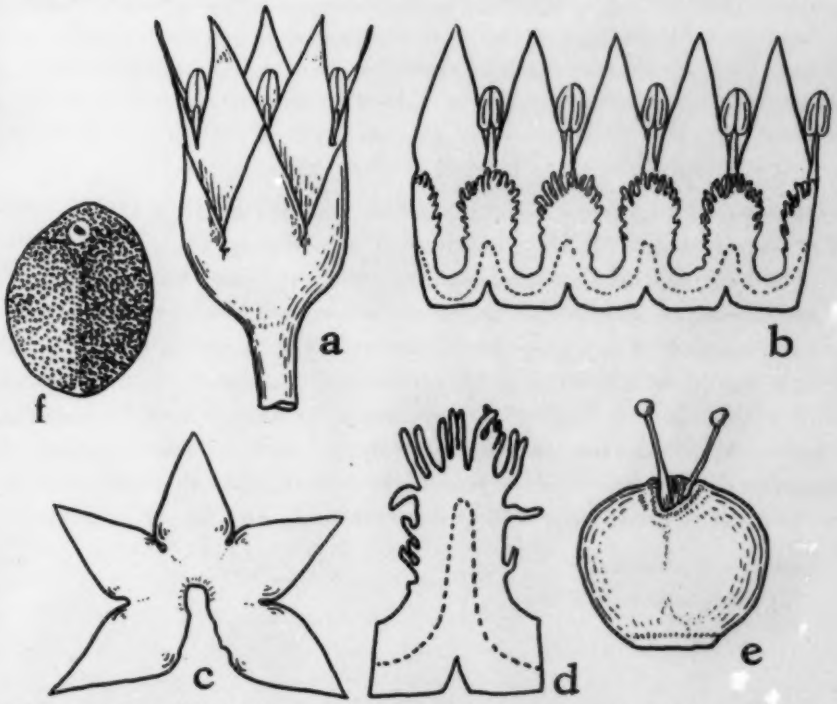



Fig. 1. *Cuscuta palustris* Yuncker, n. sp. a, flower ×*10;* b. opened corolla ×*10;* c, opened calyx ×*10;* d, individual scale ×*20;* e, capsule ×*10;* f, seed ×*20.*

plerumque longiores. Filamenta subulata; antherae ovato-longae. Squamae oblongae, fimbriatae, stamina attingentes. Styli plus minusve subulati, ovario globoso aequilongi vel breviores. Capsula depresso-globosa, membranacea, non circumscissilis. Semina 4, circ. 1.5 mm. longa, hilo brevi oblongo.

Stems moderate to slender. Flowers somewhat fleshy, 5– or sometimes 4–parted, about 2 mm. long from the base to the corolla sinuses or 3 to 4 mm. long to the tips of the erect corolla lobes, on pedicels about equaling the length of the flowers, in paniculate-cymose clusters. Calyx more membranous than

the corolla and yellow when dry, lobes somewhat thickened medianally, longer than the corolla tube, ovate-lanceolate, sharply acute, overlapping but abruptly narrowed at the base to form an obtusely rounded sinus, margins essentially entire. Corolla somewhat fleshy, campanulate, enlarging and remaining about the base of the mature capsule, lobes at first erect but becoming reflexed as the fruit develops, equaling or mostly longer than the tube, ovate-lanceolate, sharply acute, abruptly narrowed at the base, margins entire or some lobes sparingly irregular. Anthers ovate-oblong, about as long as the stoutish, subulate filaments. Scales reaching the stamens, oblong, fringed with medium length processes, bridged below the middle. Styles more or less subulate, stoutish, about equal to or slightly shorter than the globose ovary, stigmas depressed-globose. Capsules depressed-globose, membranous 4–seeded, thin about the base and easily breaking loose from the calyx but they do not appear to be definitely circumscissile, interstylar aperature gaping. Seeds about 1.5 mm. long, oval in outline, umbilical area round, hilum short, oblique, embryo filiform, coiled.

Mexico: Progresso, Yucatan, in salt marsh, August 11–15, 1932, W. C. Steere *no. 3077.* (Type in herb. Univ. Michigan).

The type specimen is not abundant or in very good condition. A sufficient number of flowers and fruits are present, however, to show that it does not agree with any other known species. It apparently belongs in subsection Acutae of section Cleistogrammica and seems to be most closely allied with *C. acuta* Englm. of the Galapagos islands and *C. yucatana* Yuncker. It differs from both of these species with its mostly larger and somewhat fleshier flowers, more lanceolate perinth lobes which are abruptly narrowed at the base, and with stouter filaments and larger anthers.

DePauw University
Greencastle, Indiana

# Two Pocket Rots of Hardwood Trees

W. H. Long

(WITH FOUR FIGURES)

This paper describes a butt heart-rot of living trees caused by *Fomes extensus* Lev. and a honey-comb rot of dead fallen timber produced by *Polyporus rigidus* Mont.

During field investigations in Florida (1913-1918), the writer found the hymenophores of *Fomes extensus* associated with a white pocket heart-rot of three species of living trees—*Exothea paniculata* (Juss.) Radlk., *Lysiloma bahamensis* Benth. and *Taxodium distichum* (L.) L. C. Rich. This rot was always in the base of the infected trees, extending downward into the roots and also upward in the butts for a short distance (2–3 ft.).

In *Exothea paniculata*, the first indication of the rot is a slight change in the color of the heartwood, small whitish flecks appear which later increase in size. The white color is due to the delignification of the wood by the fungus leaving the cellulose intact. In early stages of the rot, the white pockets are lense-shaped and in radial section range from 2–10 mm. wide by 5–20 mm. long with their main axes parallel to the grain of the wood. These pockets are filled with white cellulose which is slowly absorbed by the attacking fungus leaving small cavities lined with the remnants of the cellulose fibers. These white pockets increase in size faster longitudinally than radially. The cross walls of the pockets, which originally ran radially are gradually destroyed by the fungus thereby causing the rotting wood to separate into thin longitudinal irregular sheets whose central layer consists of dark brown partially rotted wood.

The pockets produced in this host are very pronounced and in the last stages of the rot much, but not all, of the attacked heartwood is destroyed, leaving big pockets lined with white cellulose fibers. In the oldest stages of the rot the partially empty pockets may have a light, fluffy mass of mycelium in their centers.

Figure 1 gives a cross-section view of an advanced stage of the rot in the heartwood of *Exothea paniculata;* figure 2 shows a radical-longisectional view of the rot in the same host. The description and photographs were made from specimens of the rot in the living exposed roots found near Miami, Florida.

*Fomes extensus* causes a rot in the heartwood of *Lysiloma bahamensis* very similar to that in *E. paniculata*, however the rot pockets are smaller in cross-section view but have the same tendency to coalesce longitudinally

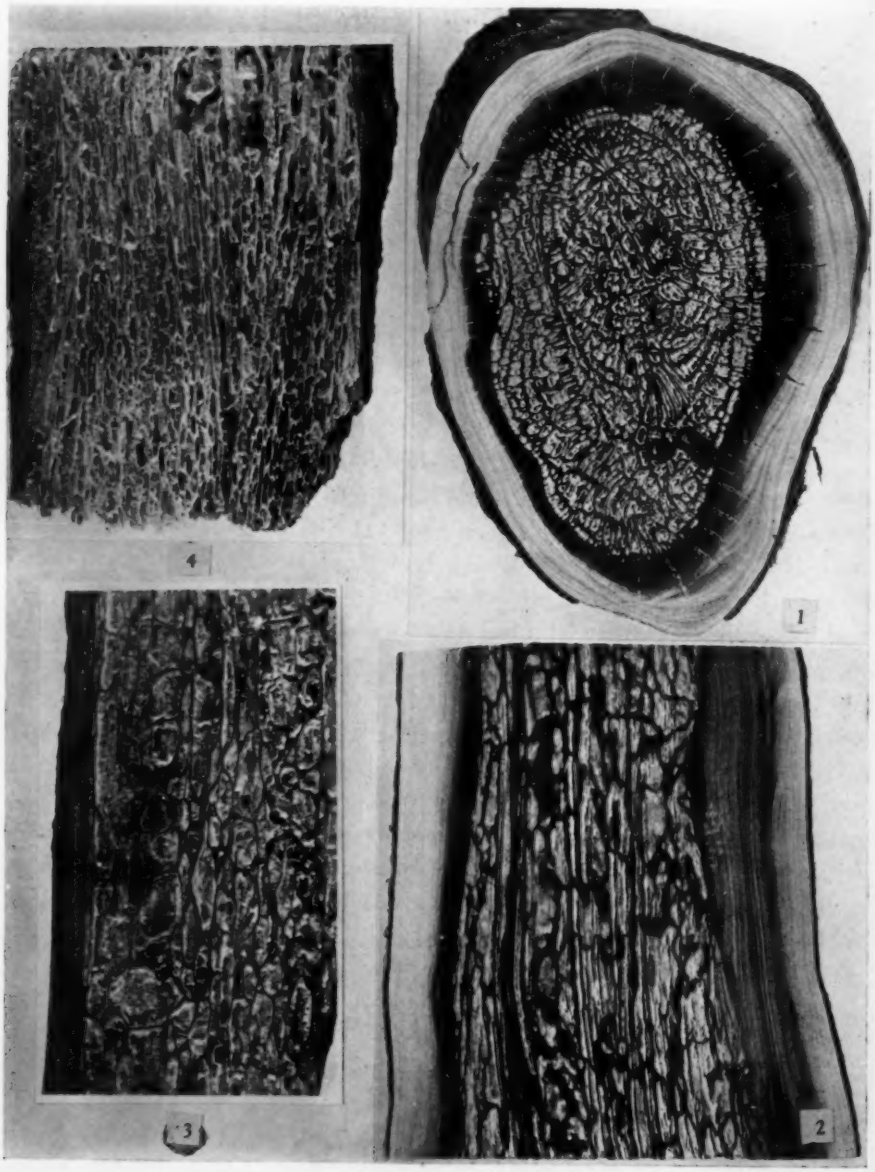



Fig. 1. *Fomes extensus* rot in roots of *Exothea paniculata,* Miami, Fla. Cross-section view. ×¾.

Fig. 2. *Fomes extensus* rot in roots of *Exothea paniculata,* Miami, Fla. Radial-longisection view. ×¾.

Fig. 3. *Polyporus rigidus* rot in *Liquidamber styraciflua* long Lake Village, Ark. Radial-longisection view. ×1.

Fig. 4. *Polyporus rigidus* rot in *Liquidamber styraciflua* log, Cass, Ark. Tangential-longisection view. ×1.

thereby producing a continuous line of delignified rot. With age many of these pockets are filled with a brown mycelium. This description was made from specimens of the rot in *L. bahamensis* collected near Miami, Florida.

*F. extensus* was also found associated with a heart-rot in the butts of living trees of *Taxodium distichum*. The rot pockets in this host are much larger than those in the other two hosts given above. These pockets ranged from 1–2 cm. wide by 4–8 cm. long. Only a trace of the cellulose fibers were left in the specimens at hand. The pockets were empty except for a thin whitish arachnoid mycelial membrane on the walls. The partitions separating the pockets were very thin (0.5–1 mm. thick). This description was made from specimens of the rot found near Palatka, Florida, in the butt of a living tree, directly associated with a hymenophore of *Fomes extensus*.

While investigating forest tree diseases in the Mississippi River Valley (1913–1918), the hymenophores of *Polyporus rigidus* were found associated with a characteristic honey-comb rot in the logs and stumps of *Liquidamber Styraciflua* L. This fungus was also found attacking the dead fallen trees of *Nyssa aquatica* Marsh, *Platanus occidentalis* L. and *Quercus alba* L., but the rot found in these three species was not as pronounced a pocket rot as that in *L. Styraciflua*.

The rot pockets produced by *P. rigidus* in *L. Styraciflua* are lenticular and in the last stages are filled with a white arachnoid mycelium. In radial-longisection these pockets are broad and are bounded by the medullary rays of the wood. They are longer than broad, being 0.5–1 cm. broad by 1–2 cm. long (fig. 3). In tangential-longisection these pockets have a very different appearance, being 0.2–0.5 cm. thick by 1–2 cm. long (fig. 4). In the final stages of this rot the infected wood becomes very light and of a honey-comb consistency. No early stages of the rot were seen. This fungus was found in Arkansas, Mississippi, Tennessee, Texas and Virginia.

Dr. L. O. Overholts, who kindly identified my material of *Polyporus rigidus*, states in a recent letter, that he has also found *P. rigidus* producing a conspicuous pocket rot in the south and that it is very similar to the rot caused by *Polyporus zonalis* Berk. in the same region. He says that *P. rigidus and P. zonalis* are closely related, having the same minute thick-walled tubes, similar spores, hyphae and basidia and in the peculiarly hardened condition of the dried specimens of each.

*Polyporus rigidus* is usually resupinate but occasionally develops a very narrow reflexed pileus. The resupinate material has been identified by some American and European botanists as *Poria undata* (Pers.) Bres.

ALBUQUERQUE, NEW MEXICO

# A New Forest Climax: the Salt Spray Climax of Smith Island, N. C.

B. W. Wells

(with two figures)

Smith Island, N. C. (locally called Bald Head Island) has always been of unusual interest to botanists because of the high dominance of live oak on its upland areas together with the fact that the cabbage palmetto reaches its most northerly limit here.

A glance at a map of the eastern shore line of the United States will show that the tip of Cape Fear is on this island and the island bounds the eastern side of the mouth of Cape Fear River. It is made up of a series of 3 narrow sand uplands alternating with 2 salt-marsh lowland areas and extensive salt marshes to the north (fig. 1). The long axes of these physiographic structures are approximately east-west. By far the largest of these land strips is the most southerly one which, according to the latest hydrographic map (Geodetic Survey), is 3 miles long and ½ mile wide at the eastern end, but a mile wide at the western end.

The inland two-thirds of this "main island" is covered with a unique forest of live oak (*Quercus virginiana*)—unique in the sense that this tree here forms a practically pure stand with crowns meeting (fig. 2), except for an occasional palmetto (Sabal palmetto) holding its mass of fan-like leaves 20–30 feet in the air. Earlier there was a second important tree, through not to be regarded as subdominant; viz., the red cedar (*Junipus virginiana*). This tree was cut extensively in the past leaving the oak to assume an unusually high degree of dominance. These oaks today give every evidence of being climax. Very old living trees with trunk diameters of 3–4 feet are frequent, and scattered in them one encounters disintegrating trunks of even larger trees. In addition to this direct evidence, a report on the Island made in 1805 by J. G. Swift, an officer in the U. S. Army, states concerning the mouth of the Cape Fear River; "On Smith Island there is a growth of live oak and palmetto." There can thus be no question of the climax status of this forest.

The topography of the forested area is of a low rolling type, the local elevations 5–10 feet high representing small dune relics. The live oaks occupy the low flat areas as well as the dune summits. The soil is sufficiently high in humus to give it a loam structure. The high degree of maturity reached is reflected in the frequency with which the flowering dogwood is present under the canopy of live oaks. Under the rainfall (average of 50

inches recorded at nearby Southport) this soil may be regarded as definitely mesic and favorable for the growth of the ordinary broad-leaved climax species of the region; viz., white, black, and southern red oaks or even beech and southern sugar maple.

Yet these trees are wholly absent and the accompanying undergrowth is largely made up of the shrubs *Batodendron arboreum*, *Myrica cerifera*, *Ilex vomitoria*, *Osmanthus americanus*, *Callicarpa americana*, and the small trees, *Persea borbonia*, *Prunus lauro-cerasus* and *Ilex opaca*.

On the mainland, and back a mile or more from the sea, in sharp contrast to the Island, the live oak nowhere assumes dominance, or subdominance. In North Carolina it disappears almost completely a few miles from the sea if the numerous transplants to private grounds are ignored.

Mohr (1) has earlier pointed out that "*Quercus virginiana* is a tree of the sea coast. It approaches in a high state of development the Carolinian area near the northern limit of eastern North Carolina and extends westward along the Gulf coast to Texas and northern Mexico. In the Gulf states the live oak is rarely found above the 31st parallel."

It is the purpose of this paper to explain this local dominance of *Quercus virginiana* along our eastern and southern coast and to show that this tree when it reaches high dominance and stabilization constitutes a new and heretofore unrecognized kind of climax.

Wells and Shunk (2) working on the coastal vegetation of the Cape Fear Peninsula discovered that the characteristic sloping forms of the woody plants nearest the sea, which had heretofore always been ascribed to wind, are not directly due to wind but are produced by the killing or blighting action of the salt water spray carried by the wind. Full proof of this assertion was found in the numerous examples of the same coastal woody plants which occupied sites fully exposed to the wind but far enough back from the sea to remove them from the spray zone. Such shrubs and trees showed no detectable modification of their contours.

In making these original observations it was quickly noted that the live oak was the only dicotyledonous tree (*Myrica cerifera* and *Ilex vomitoria* are seen chiefly as shrubs) which can tolerate the medium spray intensity or occupy the middle spray zone sites. It is not as resistant to the spray injury as the two shrubs just mentioned. Correlated with the relatively high spray resistance of live oak are the structural characteristics of its sclerophyll leaf, with its thick cutin and absence of stomata above, and the closely spaced myriads of stellate trichomes below preventing any ready access of water to the stomatal bearing surface.

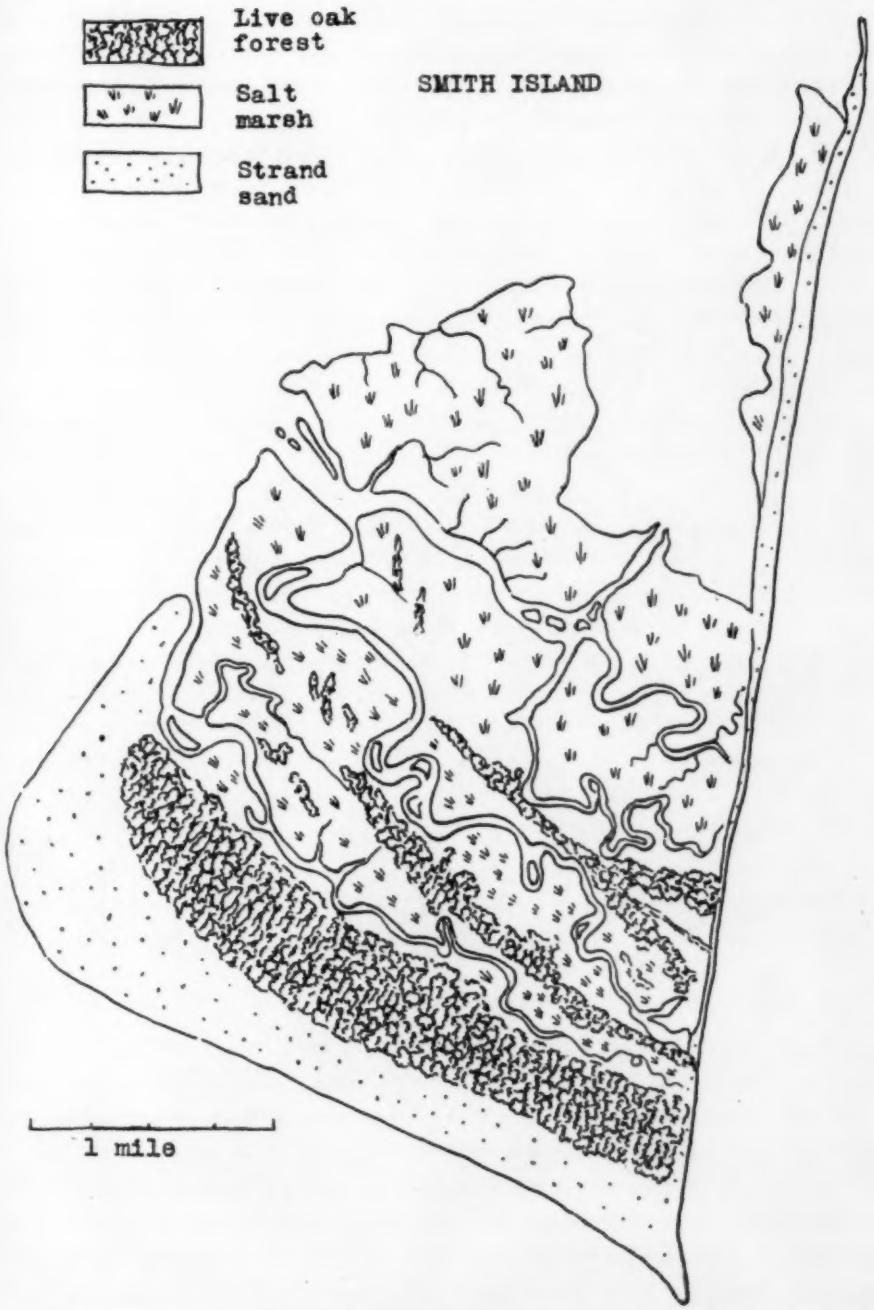



Fig. 1. Map of Smith Island showing distribution of live oak (*Quercus virginiana*) and other principal types of vegetation.

Thus, as a corollary of this discovery, it appears that on Smith Island which, because of its exposed position, is swept by spray during the higher winds, we observe the selection of the one dicotyledonous tree strongly resistant to this killing agent. A slow growing tree, yet requiring a favorable mesic, soil habitat, it may only attain dominance when freed from the competition of other trees, the hardwoods which cannot enter the spray zone. It is thus the spray factor which largely accounts for the statement that the live oak is a "tree of the sea coast."

In light of these observations a new and heretofore unrecognized type of climax becomes known. Such a climax may properly be called the "salt spray climax" which gives emphasis to the factor which brings the live oak to dominance.

Such a climax must have its seral story, which may be concisely given since the number of spray plants is highly restricted. The pioneer on the sand flats is, in the Cape Fear region, the sea oats (*Uniola paniculata*). This grass initiates the dunes and is the single dominant which can stand the high spray intensity. On older areas in the medium spray zone *Myrica cerifera*, *Ilex vomitoria* and often *Juniperus virginiana* come in as a shrub stage. This will be followed by the live-oak-forest climax.

The discovery of such a climax as the salt spray climax is of additional interest in connection with the concepts of mono-versus polyclimaxes. In this salt spray climax habitat we have a direct factor which is dependent upon an indirect climatic factor (wind) for its effectiveness. So long as the shore lines are relatively stable, this spray factor, which is even more stable, thus becomes a climax maker in its own peculiar way. This means that the usual coastal inland sere cannot take place on the ocean front and produce there the usual climax. It thus becomes necessary here to adopt the polyclimax concept for the general coastal region.

## SUMMARY

Based upon observations reported recently (3), it has been found that live oak (*Quercus virginiana*) is the only broad leaved dicotyledonous tree, the mature leaves of which can withstand the destroying action of moderate salt spray.

Smith Island, a land area 3 miles wide at the Cape Fear angle of the eastern U. S. coast line, is covered with a nearly pure stand of very old climax live oaks, under which dogwoods indicate the high degree of soil maturity. Since we have shown that wind is not the factor controlling the zonation of the coastal dune plants and the form modification of the

woody ones, we are forced to the conclusion that in the history of the island, salt spray is the selective factor in bringing about the dominance and persistence of the salt-resistant live oak. It is further suggested that the spray factor largely accounts for the distinctive coastal distribution of live oak as a dominant throughout its range.

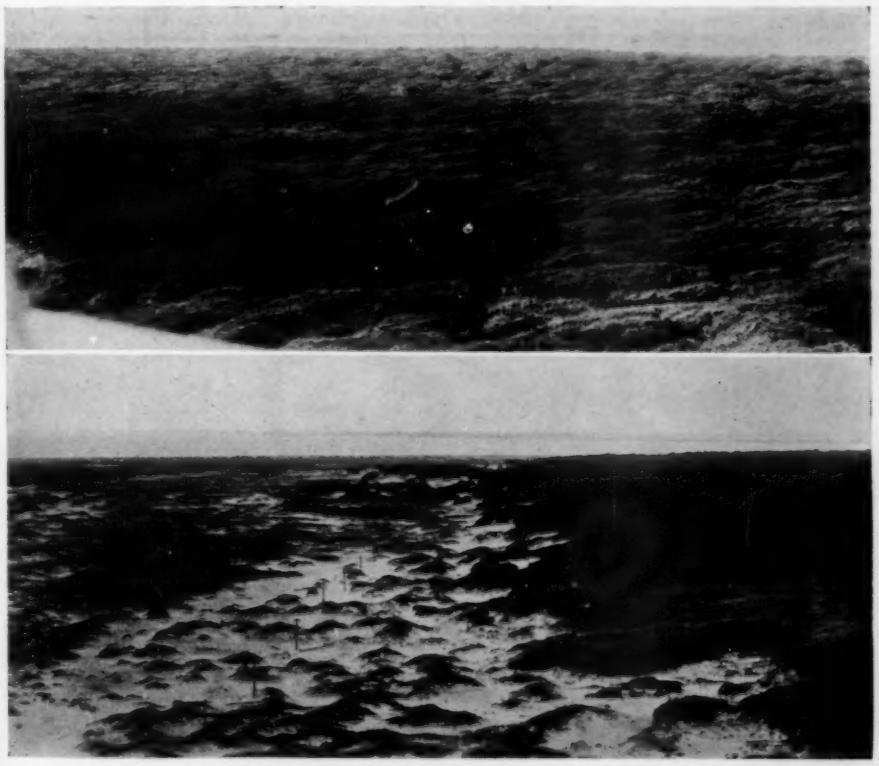


Fig. 2. Above. View across spray climax showing high dominance of live oak. Note striated appearance due to asymmetric growth of individual trees and tree groups. Below. Strand in front of forest on south side of the Island. Vertical lines are telephone posts. Both views taken from Coast Guard tower, 120 ft. high.

This discovery of a climax dependent upon a direct factor which in turn is dependent upon a climatic factor (wind) indicates that for the general coastal region the polyclimax concept must be held.

College of Agriculture
University of North Carolina
Raleigh, North Carolina

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# INDEX TO AMERICAN BOTANICAL LITERATURE

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

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# INDEX TO VOLUME 66

New species and the final members of new combinations are in **bold face type.**


Abies 58, 447, 449; balsamea 462; concolor 452, 462; grandis 216, 219; lasiocarpa 216
Acer 187, 219; glabrum 219; glabrum Douglasii 466; Negundo 461; platanoides 461; rubrum 370, 386, 466, 486; saccharinum 460, 461; Saccharum 461
Achillea borealis 456
Achlya 252; flagellata 261
Acroporium guianense 229; pungens 229
Actidesmium 504
Actinocheita 636
Actinomyces discofoliatus 188; erythropolis 498; scabies 425
Additions to Florida fungi—I 29
Additions to the algae of Michigan 77
Additions to the flora of the Glacier Bay National Monument, Alaska 453
Adiantites 301
Adromischus subcompressus 132
Aegiphila 257
Agapanthus 162
Agaricus 29, 152; floridanus 152; iodoformicus 335; placomyces badius 152; pocillator 152; projectellus 152; **Rhoadsii** 29; subrufescens 30; sylvicola 152; **Weberianus** 29
Agave 127
Agrolimax 1
Agropyron 186, 317, 323, 324, 337; divergens 327; glaucum 337; inerme 327, 497; repens 324; spicatum 217, 327, 328, 497; spicatum inerme 328
Agropyron spicatum and A. inerme, The Taxonomy and Ecology of 327
Agrostis exarata 453
Ailanthus altissima 637
Alaska, Additions to the flora of the Glacier Bay National Monument 453
Alcicornopteris 298, 302
Algae of Michigan, Additions to the 77
Alisma 540
Allium 57, 162
Allomyces arbuscula 60
Allopuccinia 179
Alnus 219, 470, 472; rubra 456; rugosa 372, 386; sinuata 456, 470
Alternaria tomato 504
Amalia 1
Amanita 152, 153; alliacea 153; anisata 153; caesarea 1; flavoconia 152; flavorubescens 152; gemmata 152; mappa 1; muscaria 1; odorifera 153; pantherina 1; phalloides 1, 152; porphyrea 1; pustulata 1; **Rhoadsii** 37; Roanokensis 152, 153; rubescens 1; spissa 1; strobiliformis 1; suballiacea 153; umbrina 1; verna 4, 5, 152; virosiformis 153
Amaryllis 429
Amelanchier oblongifolia 378, 386
American Botanical Literature, Index to 53, 124, 180, 250, 330, 420, 495, 573, 635
Amianthium muscaetoxicum 573
Ammophila arenaria 617, 618; breviligulata 618
Ampelamus 611, 613; albidus 611
Amphizoma 232, 238–240
Amphorophora rubi 255
Amsonia tabernaemontana 129
Anabaenopsis elenkini 78
Ananas 644
Anaphalis margaritacea occidentalis 456
Anaueria 186, 256
Anchistea virginica 380, 384
Ancylistes 54
Andreaea Rothii 97, 114
Androstephium 163
Androtrichum 181
Aneimites acadica 301
Anemia 273; phyllitidis 279; narcissiflora 456; quinquefolia 374, 386
Angiopsora 620
Aniba 186, 256
Annona Ambotay 306, 310
Antennaria plantaginifolia 388
Anthodon grandiflorus 247
Antirrhinum 182
Aphanocapsa castagnei 78
Apical Meristem in the shoots of Taxodium distichum, The structure and development of the 431
Apios tuberosa 373, 386
Aplanobacter stewarti 422

Apodachlya 252
Apogamy in Pteris cretica Linn. var. albolineata Hod., The cytology of 549
Arabis hirsuta 456; lyrata 454; lyrata glabra 456; pycnocarpa glabrata 456; viridis heterophylla 422
Arachnopeziza 259
Arbutus pilosa 23; xalapensis 22
Archaeopteris 303; Bochschiana 301
Ardisia crenata 647; crispa 647
Argemone platyceras rosea 645
Argomycetella 174, 175; dolichospora 174; pressa 174, 175, 177; pura 174, 175, 178
Argyroxiphium 617; sandwicense 617
Arion 1; subfuscus 1
Arisaema triphyllum 378, 385
Aristida oligantha 464
Armillaria 1; alphitophylla 31, 151; Boryana 31, 151
Arnica latifolia 456
Arnold, Chester A., Lagenospermum imparirameum sp. nov., a seedbearing fructification from the Mississippian of Pennsylvania and Virginia 297
Artemisia tridentata 217, 332
Arthrobotryum 577
Arthrodesmus bulheimii subincus 83; phimus 83; phimus occidentalis 83; triangularis inflatus 83
Arum maculatum 539
Aruncus sylvester 456; vulgaris 456
Arundinaria tecta 382
Asarum 289; canadense 288
Asclepiads, Some incorrectly described 605
Asclepias 606, 608–611; brachystephana 606; curassavica 606; debilis 605; incarnata 606; incarnata pulchra 373, 387; parviflora 605, 606; perennis 605–611; perennis parvula 607; pulchra 606; quadrifolia 606; texana 607, 610; Texensis 606; Syriaea 613
Asclepis 181
Ascyrum hypericoides 387
Ashbya 149; gossypii 139–145, 148–150
Asparagus 546
Aspergillus flavus 186; niger 260, 644; tamarii 186
Aspidium 47; confertum 47, 51; falcatum 550, 551, 559; filix-mas 561; filix-mas cristata 550, 551, 559, 560; glandulosum 47; heterodon 51; Hookeri 51; ludovicianum 502; meniscioides 47, 50; remotum 550, 551, 559, 560
Asplenium platyneuron 378, 384
Aster 125, 373, 375; amethystinus 648; lateriflorus 388; multiflorus 464, 648; novae-angliae 648; novi-belgii 380, 388; paniculatus 376, 388; surculosus 388; tardiflorus 388; tradescanti 388; vimineus 388
Athyrium acrostichoides 374; asplenioides 378, 384; filix foemina clarissima 550; thelypteroides 378, 384
Atrichum 250; Macmillani 250
Atriplex argentea 217
Auxin, Further analysis of the pea test for 391
Avena 124, 260, 499, 539, 576, 638
Azalea 287, 289
Azolla 275
Azotobacter 61, 136, 191; agilis 644

Baccharis 620; glutinosa 620; halimifolia 373, 388
Bacillus subtilis 189
Backus, Myron P., The mechanics of conidial fertilization in Neurospora sitophila 63
Bacterium tardicrescens 129
Bailey, I. W., The microfibrillar and microcapillary structure of the cell wall 201
Balsamorhiza sagittata 217
Baptisia 185
Barbula 93–97, 104, 111–113, 116–118, 428; acuminata 93, 95, 106; acuta 96, 97, 99, 107, 108, 115; agraria 93, 96, 97, 103, 111; amplexa 97; andreaeoides 97; apiculata 93, 97; artocarpa 97, 117; astoriensis 95; Bakeri 98, 99; Beecheyi 98, 102; Bescherellei 98; Bolanderi 95; brachyangia 95; brachyphylla 98, 99, 103, 109, 110, 116; brachyphylla angustifolia 116; brachypoda 95; brevipes 95; cancellata 100–102; carnifolia 95; chrysopoda 99, 101; circinnatula 100, 102; Closteri 100, 101; convoluta 99–101, 105; Cruegeri 100–102, 108, 111; cylindrica 94, 98–100, 102–108, 110, 112, 115–117; cylindrica vinealis 116; decursivula 103, 106; Dieckii 103, 112; Donnellii 103; Egelingi 95; Ehrenbergii 103, 104; elata 104, 105, 117;

eustegia 105, 106, 110; fallax 96, 98, 103, 106, 109, 111, 114, 115, 117; flavipes 106; flexifolia 93, 102, 106, 117, 118; gracilis 95–97, 107, 115, 117; gracilis squarrulosa 95; Hornschuchiana 110; horridifolia 102, 107; icmadophila 95, 107; indigens 107, 108, 116; insulana 102, 108; Johansenii 108; Jooriana 101, 102, 108; laeviuscula 95; lanceolata 93, 108; lateritia 109, 116; latoexcisa 95; leptotricha 95; macrotricha 95; megalocarpa 95, 109, 112; michiganensis 106, 109; oenea 109; papillinervis 95; perannulata 105, 110; platyneura 110, 114; pseudoaciphylla 95; pseudorigidula 102, 110; purpurea 99, 110, Raui 96, 103, 111; Ravenelii 101, 111; recurvifolia 111; reflexa 106, 109, 111; revoluta 114; rigens 111; rigidula 98, 110–113; robustifolia 102, 112; rotunda-emarginata 95; rubiginosa 95, 102, 103, 109, 112, 115; rufipila 95; Saundersii 113, 116; semitorta 113, 116, 117; sinuosa 113; spadicea 113; sparsidens 106, 114; spiralis 110, 114; stricta 93, 114; subandreaeoides 114; subcaranifolia 95; subcuneifolia 95; subcylindrica 102, 115; subfallax 102, 115, 117; subgracilis 115; subicmadophila 95, 112, 115; submegalocarpa 95; tortellifolia 102, 115; Treleasei 115, 116; unguiculata 95, 97, 100, 101, 108, 109, 113, 114, 116; vinealis 93, 94, 97, 98, 99, 102, 104–107, 109, 113, 115–118; vinealis flaccida 117; virescens 104, 105, 116–118; Waghornei 118

Barbula in North America north of Mexica 93

Bartonia virginica 380, 387

BARTRAM, EDWIN B., Mosses of interior British Guiana 221

Basistemon 330

Batodendron arboreum 630

Beaucarnea 588; **Amelia** 584–586, 588; guatemalensis 586; **petenensis** 586; pliabilis 588

BEAVEN, GEORGE FRANCIS and HENRY J. OOSTING, Poconoke Swamp: a study of a cypress swamp on the eastern shore of Maryland 367

Begonia 511; Rex 512; semperflorens 187

Beilschmiedia 185, 256

Benzoin aestivale 373, 386

Berberis 293; Thunbergii 462

Besleria 500

Betula 219, 470; 530; **idahoensis** 465, 468, 470; lenta 465, 468, 472; nigra 376, 386; papyrifera 461

Bidens comosa 373, 388; discoides 373, 388; laevis 388; trichosperma 376, 388

Bignonia capreolata 372, 387

Billia 499

Biotin, Preliminary experiments on 139

Bitzea 335; Ingae 173

Blakea **Mexiae** 419; paludosa 419; Spruceana 419

Blastocladia 495

Blastospora 177, 179, 335; ascotela 177; Hygrophilae 177

Blechnum 39; asplenioides 43; Buchtienii 44; capense 44; **delicatum** 41, 43; distans 41; Juergensii 41; laevigatum 41; **malacothrix** 40, 41; penna-marinum 44; Raddianum 44

Bletia 643

Boehmeria cylindrica 373, 386

Boletus 1, 4, 5, 152; ananas 152; aureissimus 152; bicolor 152; communis 152; edulis 152; felleus 152; granulatus 152; hemichrysus 152; luridus 152; pictiformis 152; pisciodorus 152; scaber 5; subflavidus 152; **umbrinisquamosus** 37

Bolivia and Peru, New ferns from 39

Bomarea 129

Boottia 187

Botanical components of Curare—II, Notes on the 305

Botanical Literature, Index to American 53, 124, 180, 250, 330, 420, 495, 573, 635

Bothrodendron 275

Botrychium lanceolatum 499; multifidum 332; obliquum 384; virginianum 378, 384

Botryosphaeria Ribis 648

Bouvardia dictyoneura 602; **venosissima** 602

Brevoortia 163, 165

Brief history of Chinese herbs and medicine, A 563

British Guiana, Mosses of interior 221

Brodiaea 161–166, 424; congesta 161, 163; Felipponei 162; grandiflora 161, 164;

porrifolia 162; Spegazzinii 162; Tweediana 162; uniflora 162
Brodiaea, A definition of the genus 161
Bromus tectorum 464
Brucella 640
Brunsvigia gigantea 429
Bryophyllum calycinum 192
Bryum coronatum 225
Buchnera 258
Buell, Murray F., Peat formation in the Carolina Bays 483
Bulbochaete angulosa 80; furberae 80; nana 80; repanda 80
Bulgaria polymorpha 1
Burkillanthus 645
Bursera heteresthes 496; tecomaca 496; trimera 496
Butia 36; capitata 35

Calamagrostis canadensis 453
Calamovilfa 618
Calathiops 297, 298, 301, 302; Bernhardti 302, 303; plauensis 302
Callicarpa americana 630
Callicostella depressa 227; rufescens 227
Calliprora 163, 165
Callixylon 331
Calochortus 421, 573
Calosphace 333, 576
Calothrix adscendens 78
Calpodium wrightii 455
Caltha leptosepala 456
Calycanthus 229; fertilis 288
Calymperes disciforme 225; Donnellii 224; lonchophyllum 225; nicaraguense 225; Richardi 223; Smithii 223, 224; Sprucei 224
Calyptospora Geoppertiana 333
Camelina sativa 463
Camp, W. H., Studies in the Ericales IV. Notes on Chimaphila, Gaultheria and Pernettya in Mexico and adjacent regions 7
Campanula 289; lasiocarpa 456; rotundifolia 288
Campylocentrum 53
Campylopus savannarum 221
Canna 422
Cantharellus aurantiacus 4, 5; multiplex 134
Capsella Bursa-pastoris 463
Capsicum annuum 581
Caragana 462
Cardiopteridium Holdeni 299, 301
Carex 260, 378; albicans 136; aquatilis 453; area 453; brunnescens 453; canescens 383, 385; crinita 373, 385; debilis 373, 385; foenea 136, 385; folliculata 373, 385; intumescens 373, 385; leptalea 453; limosa 453; lupulina 373, 385; lupulina pedunculata 385; lurida 380, 385; picta 641; pyrenaica 453; rostrata 453; serosa 373, 385; spectabilis 454; stipata 376, 385; straminea 136; stricta 385; vesicaria 385; viridula 454
Carica papaya 503
Carpinus 465, 466, 472, 518, 535; Betulus 472; caroliniana 372, 386, 465, 472; caroliniana tropicalis 472
Carya Buckleyi arkansana 452
Cascaronia astragalina 57
Cashalia 499
Cassia chamaecrista 386; marilandica 386
Cassiope mertensiana 456; stelleriana 456
Cassipourea belizensis 598; podantha 598
Castalia odorata 376, 386
Castanea 474, 517, 526
Castilleja pallida elegans 456
Casuarina 646
Catermaria 61
Cause of Pecky Cypress, The 87
Ceanothus 335; foliosus 259
Cedrus 636
Celastrus 465, 466, 480; scandens 465, 480
Cell wall, The microfibrillar and microcapillary structure of the 201
Celtis occidentalis 459
Centaurium pulchellum 387
Centradenia 289; floribunda 288
Cephalanthus occidentalis 373, 388
Cephaloziella Starkii 185
Ceratium hirundinella 615
Ceratostomella ips 636; ulmi 191, 646, 647
Chaconia 173, 178, 179, 335; alutacea 174
Chaetomorpha 493
Chamaecrista 134
Chamaecyparis nootkatensis 455; thyoides 370, 385, 486
Chamaedorea 496
Chan, Leonard, A brief history of Chinese herbs and medicine 563
Chara 251

Characiopsis longipes 78
Characium ornithocephalum 81
Charybdis 333
Chascanum 426, 500
Cheilanthes 504; alabamensis 498; andina 39
Cheiloclinium 232
Chelone glabra 373, 387
Chenopodium 290; album 463
Chilenia 182
Chimaphila 7, 331; acuminata 7; dasystemma 7, 8; guatemalensis 7, 8; maculata 7, 8; maculata acuminata 7; Menziesii 8
Chimaphila, Gaultheria and Pernettya in Mexico and adjacent regions, Studies in the Ericales IV. Notes on 7
Chinese herbs and medicine, A brief history of 563
Chionanthus virginica 372, 387
Chlamydobalanus 353
Chlorella 573, 646; vulgaris 189, 337
Chlorophytum elatum 336
Chloroscypha 134
Choanephora cucurbitarum 252
Chondodendron 308; iquitanum 306–308, 314; tomentosum 306, 308, 309, 314
Chrysler, M. A. and D. S. Johnson, Spore production in Regnellidium 263
Chrysocapsa planctonica 80
Chrysocelis 178
Chrysocyclus 178
Chrysopsis mariana 388
Chrysothamnus nauseosus 217
Chytridium 252; lagenaria 285; Olla 285; Schenkii 285; transversum 285
Cichorium 273
Cicuta maculata 375, 387
Cinna arundinacea 373, 385
Cinnamomum 330
Cirsium oleraceum 3
Cissampelos ovalifolia 309; pareira 307, 309
Cistus 292
Cladosporium 254
Cladothamnus pyrolaeflorus 456
Cladrastis lutea 339
Clercia 241
Clermontia 503; grandiflora 503
Clethra alnifolia 373, 381, 387, 486
Clidemia 418; cymifera 419; ecuadorensis 418; gracilipes 418, 419; japurensis 418; naevula 418
Clitocybe illudens 59; pinophila 157; subpinophila 156; subtruncicola 157; tabescens 258
Clitoria Ternatea 288
Closterium abruptum 83; aciculare subpronum 83
Clymenia 645
Coccoloba 583; barbadensis 593; corozalensis 587, 588, 591; Gentlei 589, 591; guyanensis 594; hondurensis 591, 593; lancifolia 593; laurifolia 593, 594; leptostachya 593; marginata 593; myana 597; Schiedeana 593; Schippii 594; spicata 594, 595, 597
Coccothrinax 635
Cocos australis 35
Coelosphaerium Kützingianum 616; Naegelianum 616
Coffea 578; arabica 54; excelsa 425
Coldenia 60; Nuttallii 339
Coleosporium Madiae 617
Colletotrichum circinans 261
Collybia 1; albida 37; aurantiaca 160; Boryana 31; castaneidisca 160; floridana 160; mammillata 160; palmarum 37
Cololejunea 183
Columnea hirta 259
Comandra pallida 55
Commelina 541, 543, 545, 547; angustifolia 540, 542, 544; coelestris 539, 540; communis 580; dianthifolia 540; graminifolia 540; hirtella 385; stricta 540; tuberosa 539
Commelina angustifolia Michx., The development of the embryo sac and the seed of 539
Commelinantia Pringlei 540, 544, 548
Conidial fertilization in Neurospora sitophila, The mechanics of 63
Coniosporium 57
Conostegia hispida 415, 416; multiflora 416; setosa 416; Poeppigii 416
Constance, Lawrence, The genus Pholistoma Lilja 341
Controlled differentiation in a plant tissue culture 507
Convolvulus arvensis 463; cneorum 58

Cooper, William S., Additions to the flora of the Glacier Bay National Monument, Alaska 453
Cooperia kansensis 135
Coprinus 1; urticaecola 498
Cordyceps 641
Coreopsis 134
Coriolopsis crocata 151
Coriolus membranaceus taxodii 152; pinsitus 151; sector 151
Cornus amomum 373, 387; canadensis 456; florida 387
Coronastrum 339
Corticium 515
Corticolus 124
Cortinarius 1; caninus 5
Coryneum 191
Cosmarium 77, 337; decoratum 83; depressum reniforme 83; globosum minor 83; humile striatum 83; isthmium 83; nasutum 83; obsoletum 83; pseudoconnatum 83; quadrum 83; repandum 83; tinctum 83
Crataegus 184
Cremanium 417, 418
Cremosperma 130
Crepis 180, 644
Crinodendron tucumanum 332
Crocus Colchicum 539
Cronartium ribicola 55, 189, 330
Cross, G. L., A note on the morphology of the deciduous shoot of Taxodium distichum 167; The structure and development of the apical meristem in the shoots of Taxodium distichum 431
Crotalaria 190; spectabilis 128
Crucigenia apiculata 81; irregularis 81; tetrapedia 81; truncata 81
Ctenoderma 579
Cucumis melo 426
Cucurbita 503; maxima 56
Cuervea 242
Cunninghamella 250
Curare—II., Notes on the botanical components of 305
Curatella americana 222
Cuscuta 333; acuta 624; compacta 373, 387; palustris 623; yucatana 624
Cuscuta from Yucatan, A new species of 623
Cyanea 424
Cyclobalanopsis 353
Cyclobalanus 353
Cyclodium 47, 48, 336; confertum 47, 51; glandulosum 47; meniscioides 47–50; rigidissimum 51
Cyclodium, On the genus 47
Cyclonexis 504
Cycloporellus iodinus 151
Cylindrocarpon radicicola 59
Cylindrocystis brebissonii 83; brebissonii minor 83
Cyperus 181; distinctus 500; Eragrostis 131; oxylepis 131; rivularis 385; virens 131
Cypress swamp on the eastern shore of Maryland, Pocomoke Swamp: a study of a 367
Cypress, The cause of Pecky 87
Cypripedium acaule 385; calceolus pubescens 252
Cyrilla racemiflora 486
Cyrtomium 550, 551, 559
Cytisus 261
Cytology of apogamy in Pteris cretica Linn. var. albo-lineata Hort., The 549

Dalbergia 176; Sissoo 176
Dalea 637
Dasylirion pliabile 588
Datura 643
Daubenmire, Rexford F., The taxonomy and ecology of Agropyron spicatum and A. inerme 327
Daucas carota 639
Deciduous shoot of Taxodium distichum, A note on the morphology of the 167
Decodon verticillatus 373, 381, 387
Definition of the genus Brodiaea, A 161
Delphinium californicum 253; cardinale 54; newtonianum 642
Derepyxis dispar 79, 80
Dermatea acerina 59
Deschampsia atropurpurea 455; caespitosa 453.
Desmatodon 103; Bushii 101, 102; Sprengelii 103
Desmatractum bipyramidatum 79, 81
Desmidium coarctatum 83; swartzii quadrangulatum 83
Desmondium 427
Desmotelium 178

Development of the embryo sac and the seed of Commelina angustifolia Michx., The 539
Dialytrichia 100; cancellata 101
Dianthus 292
Diaporthe 647
Dicaeoma Grossulariae 620
Dichelostemma 163–166; capitatum 165
Dicotyledons, Flower buds and phylogeny of 287
Dicranopteris **boliviensis** 44, 45; rubiginosa 45
Dictamnus 289; albus 288
Dictyostelium discoideum 501
Didymodon 104, 109–113; Dieckii 103, 112; recurvirostris 111; rigidulus 113, 118; rubellus 111; tophaceus 103
Digitaria sanguinalis 462
Diodia teres 378, 388; virginiana 378, 388
Dioscorea glauca 372, 385
Diothanthera 415
Diplazium mapiriense 39
Diplodia 135
Diplophlyctis intestina 285
Distichlis 317, 324
Ditylenchus dipsaci 59
Docidium baculum 83; undulatum 83
Dodecatheon pauciflorum 456
Doryopteris 221
Dracaena petenensis 586
Drosera rotundifolia 454
Dryopteris 47, 48, 61, 257, 549–551, 554, 559; **calophylla** 49; Christii 48; **clypeata** 49, 52; Goldiana × marginalis 59; idahoensis 467; intermedia 378, 384; meniscioides 49, 50; meniscioides **conferta** 47, 49, 51; noveboracense 378, 384; **paludosa** 49, 50; stipularis 560; subobliquata 48; thelypteris 378, 384; varians 49
Duchesnea indica 618, 619
Dulichium arundinaceum 376, 385

Earliella corrugata 151
Echeveria 137
Echinocereus 337; maritimus 133; pentalophus 133
Echinochloa crusgalli 385
Eclipta alba 373, 388
Ecology of Agropyron spicatum and A. inerme, The taxonomy and 327
Eight undescribed species of Melastomataceae 415
Eisenia arborea 182, 424
Elaeodendron macrophyllum 233
Elaeophorbia 56
Elakatothrix gelatinosa 80; viridis 80
Elaphoglossum 39, 500
Elaphomyces 640
Eleocharis 124, 644; obtusa 378, 385; Robbinsii 637; tuberculosa 380, 385
Elephantopus nudatus 388; tomentosus 388
Elettaria 539
Elfvingia tornata 151
Ellisia 341, 342, 344; membranacea 350; membranacea hastifolia 350–352; Nyctelea 341
Elymus virginicus 376; virginicus glabriflorus 385
Elytraria 61
Embryo sac and the seed of Commelina angustifolia Michx., The development of the 539
Empusa 648
Enslenia 611–613; albida 611, 612
Entophlyctis vaucheriae 284
Entophysalis 492, 494; granulosa 492; **marginalis** 490–492
Entosthodon Wigginsii 136
Entyloma 126
Epigaea repens 387
Epilobium 58; angustifolium 380, 387; hornemanni 456; latifolium 456; palustre 454
Epiphyllum splendidum 258
Equisetum 501; arvense 384; fluviatile 453; praealtum 134; pratense 501; telmateia 504
Erechtites hieracifolia 388; megalocarpa 645
Eremocarpus Bentham 192
Erianthus saccharoides 380, 385
Ericales IV. Notes on Chimaphila, Gaultheria and Pernettya in Mexico and adjacent regions, Studies in the 7
Erigeron annuus 464; canadensis 388; peregrinus 456
Eriogonum 187, 255; Abertianum 423; alleni 53
Eriophorum chamissonis 454; virginicum 380, 385
Eriosporangium 175, 619

Eryngium aquaticum 387
Erysiphe 3; cichoracearum 4, 5; horidula 3; polygoni 4, 5, 259
Erythrina 578
Erythrobalanus 353–356, 358–363, 648
Erythrochiton 310; delitescens 310; macropodum 310
Espostoa lanata 181; sericata 181
Euastropsis 82; richteri 79, 81
Euastrum binale hians 83; pectinatum brachylobum 83; pulchellum 83; sinuosum reductum 84; ventricosum 84
Eublakea 419
Eucapsis alpina 78
Euchlaena mexicana 55
Eucrypta 332, 342, 352
Eucyperus 428
Eugoniopteris 48
Euonymus corymbosus 502
Euosmolejeunea 191
Eupatorium hyssopifolium 388; pubescens 388; purpureum 380, 388; rotundifolium 388; serotinum 388; verbenaefolium 380, 388
Euphorbia 56; maculata 463
Eutettix tenellus 192
Eutypella 183
Evonymus americanus 373, 386
Exacum 291
Excised tomato roots in a synthetic solution, Growth of 193
Exothea paniculata 625, 626
Experiments on biotin, Preliminary 139

Fabraea maculata 58, 333
Fagus 466, 472; grandifolia 376, 386, 465, 470, 473, 574; longipetiolata 473; pacifica 472, 473; washoensis 465, 470, 472, 473, 476
Fatsia horrida 456
Feijoa 291
Ferns from Bolivia and Peru, New 39
Ferocactus acanthodes 133; unciatus 189
Festuca octoflora 464; ovina brachyphylla 453, 455
Ficus 306, 307; atrox 307; paraensis 307
Fimbristylis autumnalis 385
Fissidens radicans 221
Flora of eastern American aspect in the miocene of Idaho, A 465
Flora of the Glacier Bay National Monument, Alaska, Additions to the 453
Florida fungi—I, Additions to 29
Flower buds and phylogeny of Dicotyledons 287
Fomes 87; Auberianus 87; extensus 625–627; geotropus 87, 88, 90, 91, 152; pinicola 60, 130; ulmarius 87
Forest climax: the salt spray climax of Smith Island, N. C., A new 629
Forsythia 289; suspensa 462; viridissima 287
Fragaria 618, 619; vesca 618
Franceia droescheri 82
Frankenia 292
Franklinia 423
Fraxinus 465, 466, 481; americana 461; pennsylvanica lanceolata 370, 387, 460; quadrangulata 465, 481
Freycinetia 57
Fritillaria liliacea 260; persica 547
Frommea 619; Duchesneae 618, 619; mexicana 618; obtusa 619
Fuligo septica 4, 5
Fungi—I, Additions to Florida 29
Fungi, Oligocene Islands 151
Further analysis of the pea test for Auxin 391
Fusarium 429, 639; Graminearum 576

Galactopus rugosodiscus 32; serifluus 32, 37
Galium Claytoni 388
Galtonia 547
Ganoderma 35; Curtisii 34; sulcatum 35, 36
Gardenia 132
Gasteria 132
Gaultheria 9, 16, 23, 26–28, 331; acuminata 9–12; chiapensis 12; Conzattii 16–20, 26; Conzattii mijorum 17, 19, 20; costaricensis 21; Cummingii 18; domingensis 19, 20; glandulifera 21; Hartwegiana 14, 15; hidalgensis 13; hirsuta 23; hirtiflora 15, 16; laevigata 10; lancifolia 13, 14; lancifolia dulcis 14; Nelsonii 10; nitida 9, 10; odorata 13–16; ovata 9, 10; parviflora 18, 21; parvifolia 18, 19; poasana 21; Pringlei 10, 11; procumbens 377, 387; Schiedeana 18, 19; sphagnicola 19, 20; tacanensis 20, 21, 25

Gaultheria and Pernettya in Mexico and adjacent regions, Studies in the Ericales IV. Notes on Chimaphila 7
× **Gaulthettya** 26; **oaxacana** 26, 27
Geaster 55
Gelasinospora 75, 76; tetrasperma 75, 76
Gentiana 291; calycosa 456; formosana 621; glauca 620; humilis 454; latifolia 373; Saponaria 378, 387
Genus Pholistoma Lilja, The 341
Genus Stereum in Pennsylvania, The 515
Geoffroea spinosa 637
Geonomas 635
Gerardia purpurea 378, 387
Germination of the resting spores, Studies on Rhizophidium. III. 281
Geum calthifolium 456; macrophyllum 456
Gibberella Saubinettii 576
Ginkgo 121, 426, 442, 444, 450; biloba 121, 122, 184, 442, 452
Ginkgo, Pollen longevity of 121
Glaucocarpum 133
Gleason, H. A., Eight undescribed species of Melastomataceae 415
Gleditsia 338; triacanthos 460
Gloeocapsa 490, 492; rupestris 78
Gloeochaete wittrockiana 78, 79
Gloeocystis ampla 80
Gloeophyllum striatum 151
Gloeosporium rosaecola 125
Glomerella gossypii 191
Glossocentrum 416
Glyceria obtusa 373, 385
Glyptostrobus 167
Gnaphalium helleri 388
Gnomonia ulmea 132
Golenkinia radiata 82
Gonatozygon brebissonii 83; brebissonii minutum 83; kinahani 83; leiodermum 83; pilosum 83
Goniopteris 48
Gonium formosum 80
Gonolobus 131, 612, 613; laevis 611–613; suberosus 612
Goodyera decipiens 454
Gordonia 291
Gossypium 137, 504
Gratiola virginiana 387
Grayia spinosa 217
Growth of excised tomato roots in a synthetic solution 193
Guepinia Spathularia 251
Gundersen, Alfred, Flower buds and phylogeny of Dicotyledons 287
Gymnodinium palustre 84
Gymnopus 32; acervatus 158; **albidus** 32, 37; albistrictus 158; **aurantiacus** 157, 160; **castaneidiscus** 157, 160; **floridanus** 158, 160; **mammillatus** 158, 160; **palmarum** 32, 37; subluxurians 158
Gyroporus **umbrinisquamosus** 33, 37
Gyroweisia tenuis 428

Habenaria Andrewsii 497; clavellata 374, 385; cristata 374, 385; lacera 380, 386
Habranthus 423; robustus 58
Halenia Hintoni 496
Halicystis 60, 131, 181
Hamamelis virginiana 386
Hansen, Henry P., Pollen analysis of a bog near Spokane, Washington 215
Hapalopilus licnoides 151
Harper, Roland M., Some incorrectly described Asclepiads 605
Harposporium Anguillalae 127
Harrimanella stelleriana 456
Haworthia 132, 189
Hedyotis pressus 177
Helenium autumnale 376, 388; nudiflorum 581
Heliocarpus glanduliferus 597; **horridus** 597
Heliothis obsoleta 331
Helix arbustorum 1; aspera 1, 3; cantiana 1; fruticum 3; hispida 1; hortensis 1; nemoralis 1; rotundata 1; pericea 1; thyroides 3; virgata 3
Henoonia 499
Herbs and medicine, A brief history of Chinese 563
Hesperoscordum 163, 165
Heterachtia 539, 545
Heterodera schachtii 423
Heterotheca subaxillaris 388
Heuchera glabra 456
Heun, Alphonse L., The cytology of apogamy in Pteris cretica Linn. var. albo-lineata Hort. 549
Hexagona daedalea 151
Hibiscus 291, 376; moscheutos 387; oculiroseus 387
Hieracium gracile 456; venosum 388

Hintonella 180
Hippeastrum 429
Hippocratea 231, 242
Hirneola Wrightii 152
Histoplasma capsulatum 577
Hollenberg, George J., Some new Myxophyceae from southern California 489
Holomitrium arboreum 222
Holopedium irregulare 78, 79
Hookera 161, 163, 164; coronaria 161, 163, 164; pulchella 161
Hookeropsis Parkeriana 227
Hoover, Robert F., A definition of the genus Brodiaea 161
Horkelia 334
Hornea 181
Horneophyton 181
Houstonia caerulea 378, 388
Howea 635
Humulus lupulus 3
Hydrocotyle 337; umbellata 375, 387
Hydrocybe nitida 159; nitida lutea 159; ruber 159; subruber 159, 160
Hydrodictyon 282; reticulatum 281
Hydrotheria venosa 53
Hygrophila salicifolia 177
Hygrophorus floridanus 159; subluridus 159; subpratensis 159; subruber 160
Hymenochaete 532
Hyophila 104; tortula 225
Hyophiladelphus 96
Hypericum 61, 290, 293; canadense 387; densiflorum 290; ellipticum 290; gentianoides 290, 387; perforatum 291; virginicum 380, 387
Hypholoma 1
Hypochnus 501
Hypomyces lactifluorum 4, 5
Hypoxylon pruinatum 132
Hyptis 333

Ichnanthus 619; candicans 619
Ilex 291, 579; glabra 377, 386; opaca 371, 386, 630; verticillata 373, 386; vomitoria 630, 632
Impatiens 339; biflora 373, 386
Imperata Hookeri 504
Index to American Botanical Literature 53, 124, 180, 250, 330, 420, 495, 573, 635
Inocybe fastigata 1
Inonotus fruticum 152; ludovicianus melleus 34
Interior British Guiana, Mosses of 221
Ipomoea coccinea 387
Ips lecontei 636
Iris 293; fulva 338; hexagona giganticaerulea 338; pumila 291; versicolor 375, 385
Isactis 489
Isoetes 411, 412; virginica 411, 642; virginica piedmontana 411, 412
Isoetes virginica, A new variety of 411
Itea virginica 373, 381, 386
Iva ciliata 573
Ivesia 334
Ixora 574

Jacobina spicigera 573
Jasminum 335
Johnson, D. S. and M. A. Chrysler, Spore production in Regnellidium 263
Jouvea 315, 316, 323–325, 503; pilosa 315–317, 319, 320, 324; straminea 315–319, 321
Jouvea (Gramineae), The morphology and phylogenetic position of the genus 315
Juglans hesperia 468; nigra 461
Juliania 499
Juncus acuminatus 380, 385; arcticus 454; aristulatus 385; canadensis 385; effusus 380, 385; marginata 380, 385; setaceous 378, 385
Juniperus 462; virginiana 185, 371, 385, 461, 629, 632

Kalanchoe 636; tomentosa 574
Kalmia angustifolia 387; latifolia 377, 387
Kalmiopsis 124
Karling, J. S., Studies on Rhizophidium. III. Germination of the resting spores 281
Kippistia 232, 235–239
Kleinia chordifolia 61; fulgens 61
Kneiffia 605
Kochia scoparia 463
Krigia virginica 388
Krukoff, B. A. and A. C. Smith, Notes on the botanical components of curare—II 305
Kuehneola 173
Kunzea ambigua 53

Labordia 643
Laccaria 1
Lactaria 1; **subtestacea** 31
Lactarius deliciosus 1; piperatus 4, 5
Lactuca 504; canadensis 388
Lagenospermum 297, 302; imparirameum 297–299, 301, 302, 495; Sinclairii 301
Lagenospermum imparirameum sp. nov., a seedbearing fructification from the Mississippian of Pennsylvania and Virginia 297
Lagenostoma 297, 301; Lomaxi 299
Lagerheimia ciliata 82; citriformis paucispina 82
Lagerstroemia indica 4, 5
Lagynion ampullaceum 79, 80
Lamium amplexicaule 463
Lamourouxia 424
Larix occidentalis 216–219
Larrea 352
Lastraea pseudo-mas cristata apospora 550, 559; pseudo-mas polydactyla 549, 550
Lathyrus palustris 454
Lecidia Pringlei 499
Leersia virginica 373, 385
Lentinus crinitus 151; lepideus 134
Lenzites trabea 134
Lepanthes 190
Lepicystis Goniophlebii 39
Lepidium apetalum 463; draba 428
Lepidobalanus 354
Lepidospartum 192
Lepiota 1, 29; dryophila 154; Morgani 151; naucina 153; **praegraveolens** 153; **rubriceps** 153; **subcristatella** 154; **subdryophila** 154
Leptarrhena pyrolifolia 456
Lepturus 319, 321, 323
Leucobalanus 353–356, 358–363, 648
Leucobryum Martianum 222
Leucocoryne 162; ixioides 466
Leucoloma serrulatum 222; tortellum 222
Leucothoë racemosa 373, 387
Ligustrum amurense 462
Lilium 54, 121, 123; auratum 121; hansonii 53; Henryi 547; superbum 378, 385
Limax 1; cereus 1; maximum 1, 4, 5
Limosella 503
Linanthus grandiflorus 645
Linaria canadensis 387
Linum 291; virginianum 386
Lipocarpha 181
Liquidambar 536; styraciflua 370, 386, 626, 627
Liriodendron tulipifera 376, 386
Literature, Index to American Botanical 53, 124, 180, 250, 330, 420, 495, 573, 635
Lithospermum croceum 259
Lobelia 429; cardinalis 375, 388; inflata 388; puberula 388
Loiseleuria procumbens 456
Lolium 317, 323 324
Lomaria brasiliensis 43
Lonchocarpus utilis 306, 310
Long, W. H., Two pocket rots of Hardwood trees 625
Longevity of Ginkgo, Pollen 121
Lonicera 287, 289; fragrantissima 287; japonica 372, 388; sempervirens 388; tatarica 462
Lophodermium pinastri 141, 142, 144, 148, 149
Lorinseria arcolata 373, 380, 384
Lotus Berthelotii 58
Ludvigia alternifolia 373, 380, 387; linearis 387; palustris 378, 387; sphaerocarpa 380, 387
Lundell, C. L., Studies of Mexican and Central American Plants VIII 583
Lupinus 177; nootkatensis 456; paniculatus 176; ramossimus 177; saxatilis 176; soratensis 176; tomentosus 176
Lutkea pectinata 456
Luzula piperi 456
Lycoperdon caelatum 1
Lycopersicum chilense 424; esculentum 424
Lycopodium 447; alopecuroides 381, 384; complanatum 377; complanatum flabelliforme 384; pendulinum 39; sitchense 455
Lycopus rubellus 373, 387; virginicus 387
Lyginopteris 302
Lygodium 274, 278; palmatum 54
Lymantria 184
Lyonia ligustrina 373, 387
Lysiloma bahamensis 625, 627
Lysimachia terrestris 387

Machaerocereus eruca 134
Macrocalyx 344; membranaceus 350

Macromitrium mucronifolium 225; stellatum 226; tumidulum 226
Macrophomina phaseoli 53
Macroscapa 163
Macrosiphum solanifolii 188
Macrosporium sarcinaeforme 641
Madia 617
Magnolia 288, 293; grandiflora 91; oregoniana 465, 480; virginiana 371, 386, 465, 480
Mahonia Swaseyi 334; trifoliolata 334
Mains, E. B., New and unusual species of Uredinales 617; Studies in the Uredinales, the genus Maravalia 173
Mainsia 173
Malaxis monophyllos 124
Mallomonas caudata 80
Mammillaria inaiae 332; insularis 58
Marasmiellus **oligocinsulae** 160
Marasmius 158; **domesticus** 160; **oligoinsulae** 160; pyrinus 574
Maravalia 173—175, 178, 425; achroa 173, 175, 176; albescens 173, 174; ascotela 173, 175, 177; Crotolariae 173, 175; **elata** 176; hyalopsora 173; Hygrophilae 173, 175, 176; pallida 173, 175; **pressa** 177; **pura** 178; utriculata 173
Maravalia, Studies in the Uredinales, the genus 173
Marsilea 263, 264, 266, 268, 270, 273, 274–277, 279, 561; Drummondi 550, 551; quadrifolia 270, 279
Marsoniella elegans 78, 79
Maryland, Pocomoke Swamp: a study of a cypress swamp on the eastern shore of 367
Mastigosporium 135
Maxon, William R. and C. V. Morton, New ferns from Bolivia and Peru 39
McCollum, R. L., The development of the embryo sac and the seed of Commelina angustifolia Michx. 539
Mechanics of conidial fertilization in Neurospora sitophila, The 63
Medicago sativa 182
Medullosa 643; distelica 643
Megachytrium Westonii 285
Megalodonta 643
Melampsora farlowii 639
Melanobalanus 354
Melilotus albus 421
Melosira granulata 616
Meniscium 48, 61
Menyanthes 620
Menziesia ferruginea 456
Mesembryanthemum 292
Meteoriopsis patula 226
Mexican and Central American plants VIII, Studies of 583
Mexico and adjacent regions, Studies in Ericales IV. Notes on Chimaphila, Gaultheria and Pernettya in 7
Mexico, Barbula in North America north of 93
Michigan, Additions to the algae of 77
Miconia **cayumbensis** 416, 417; **cremadena** 417; longifolia 417; minutiflora 417; puberula 417
Micrasterias apiculata fimbriata spinosa 84; conferta hamata 84; conferta novae-terrae 84; expansa 84; muricata 84; radiata gracillima 84; sol ornata 84
Microcapillary structure of the cell wall, The microfibrillar and 201
Microcystis **ovalis** 491, 493, 494; **splendens** 491, 493
Microfibrillar and microcapillary structure of the cell wall, The 201
Microporellus mutabilis 151
Microsphaera alni 2–5
Microsporum lanosum 333
Microthamnion kuetzingianum 80
Microtropis 129
Mikania scandens 373, 388
Milla 162, 163
Mimulus alatus 378, 387; langsdorfii 454, 456; ringens 378, 380, 387
Mirabilis jalapa 59
Mitchella repens 374, 377, 388
Mittenothamnium diminutivum 230
Moenkemeyera 185
Mollisiella 338
Monarda punctata 387
Monerma 321
Monilia 63; sitophila 76
Monotropa uniflora 387
Morchella esculenta 1
Morphology and phylogenetic position of the genus Jouvea (Gramineae), The 315
Morphology of the deciduous shoot of Taxodium distichum, A note on the 167
Morton, C. V., On the genus Cyclodium 47

Morton, C. V. and William R. Maxon, New fern from Bolivia and Peru 39
Morus 462; alba 451
Mosses of Interior British Guiana 221
Mougeotia nummuloides 82; tenuis 82
Murrill, William A., Additions to Florida fungi—I 29; Oligocene Island fungi 151; The cause of Pecky Cypress 87
Mycena 502; alcalina 1; seriflua 37
Mycophagist, The snail Polygyra thyroidus as a 1
Mycosphaerella berkeleyii 640
Myosotis 182
Myrica carolinensis 386; cerifera 377, 381, 386, 630, 632
Myrtus 291
Myxohyella 490; seriata 489, 491

Naias 540
Najas 643
Naucoria 181
Neckeropsis undulata 226
Nematospora gossypii 139, 150
Nemophila 341, 342, 344; arizonica 348; aurita 346; aurita arizonica 348; breviflora 342; erodiifolia 349, 350; membranacea 350; racemosa 349
Neocinnamomum 330
Neoporteria 182
Nephrochytrium stellatum 183
Nephrodium 47, 562; confertum 51; hirtipes 550, 551, 559; 561; meniscioides 50; molle 550, 551, 559, 560; pseudo-mas cristata 550; varians 49
456, 620
Nephrophyllidium 620; crista-galli 454
Nereocystis 254
Nerine curvifolia 576
Nesoluma 425
Netrium digitus lamellosum 83
Neurospora 65, 68, 74–76, 579; crassa 186, 335; sitophila 63, 64, 66, 68, 72–75, 420; tetrasperma 74–76
Neurospora sitophila, The mechanics of conidial fertilization in 63
New and unusual species of Uredinales 617
New ferns from Bolivia and Peru 39
New forest climax: the salt spray climax of Smith Island, N. C., A 629
New Myxophyceae from Southern California, Some 489
New species of Cuscuta from Yucatan, A 623
New species from Tetraedron from Minnesota, A 615
New variety of Isoetes virginica, A 411
Newcomer, Earl H., Pollen longevity of Ginkgo 121
Nicotiana 254, 334, 503, 512; glauca 508; langsdorffii 508; phylesis 330
Nigroporus vinosus 151
Nitella 56, 126, 131, 183, 188, 337; clavata 133
Nolina 588; pliabilis 588
North America north of Mexico, Barbula in 93
Note on the morphology of the deciduous shoot of Taxodium distichum, A 167
Notes on Chimaphila, Gaultheria and Pernettya in Mexica and adjacent regions, Studies in Ericales IV. 7
Notes on the botanical components of Curare—II 305
Notholaena Eckloniana 549
Nothrotherium 128
Notoptera brevipes 619; scabridula 619
Nyctelea 344; membranacea 350
Nymphaea 219; advena 374, 375, 386; tetragona 580
Nymphoides aquaticum 252
Nyssa aquatica 627; biflora 370, 382, 387; sylvatica 370, 387; uniflora 609

Oakesia sessilifolia 385
Oaks indigenous to the United States—I. The importance of secondary Xylem in delimiting Erythrobalanus and Leucobalanus, Secondary vascular tissues of the 353
Obolaria virginica 387
Octoblepharum albidum 222, 325; cylindricum 222
Odontostephana 613
Oedogonium 77; ambiceps 81; exocostatum 80; minisporum 78–80; mitratum 81; oblongum fusiforme 81; oblongum minus 78, 79, 81; psaegmatosporum 81; stellatum 81
Oenothera 605; biennis 387
Oligocene Islands fungi 151

Olivea 178
Olpidiopsis 643
Olyra latifolia 621; micrantha 621
On the genus Cyclodium 47
Onoclea sensibilis 378, 384
Oosting, Henry J. and George Francis Beaven, Pocomoke Swamp: a study of a cypress swamp on the eastern shore of Maryland 367
Ophiobolus graminis 576
Ophiocytium capitatum longispinum 78
Opuntia brevispina 254; humifusa 333; microdasys 134
Orchis spectabilis 137
Orontium aquaticum 375, 385
Orthostichopsis crinita 226; tetragona 226
Osmanthus americanus 630
Osmunda 54; cinnamomea 251, 373, 384; javanica 561; regalis 373, 384, 551, 561
Ostrya 472, 530
Overholts, L. O., The genus Stereum in Pennsylvania 515
Oxypolis Canbyi 498; rigidior ambigua 387; rigidior longifolia 374
Oxyria digyna 456

Papaver 292
Parathesis macronema 496; tetramera 496
Parnassia kotzebuei 454; parviflora 454
Paspalum 579; laeve 385
Passiflora caerulea 184
Paxillus 1
Pea test for Auxin, Further analysis of the 391
Peat formation in the Carolina Bays 483
Pecky Cypress, The cause of 87
Pediastrum 82; boryanum 82; duplex cohaerens 82; integrum glabra 82; tetras 82
Pedicularis lanceolata 387
Peganum 293; harmala 291
Pellaea atropurpurea 550, 551, 559, 561; glabella 499, 561
Peltandra virginica 374, 375, 385
Peltochlaena 48
Peltogyne 57
Penicillium 497, 498, 569–571
Peniophora 515; cinerea 337
Penium cucurbitinum minor 84; exiguum 84; minutum 84
Pennsylvania and Virginia, Lagenospermum imparirameum sp. nov., a seed-bearing frutification from the Mississippian 297
Pennsylvania, The genus Stereum in 515
Penstemon 60, 497; Whippleanus 573
Penthorum sedoides 378, 386
Peonia 191
Pereskia 292
Peridinium pusillum 85; willei 85
Peritassa 233
Perkinsiella vastatrix 642
Pernettya 22, 23, 25–28, 331; buxifolia 23, 25; ciliata 22, 23, 25–28; coriacea 25; hirsuta 23, 26, 27; mexicana 24, 26; obovata 24–26; Pentlandii 22; pilosa 23; prostrata Pentlandii 22; Tomasii 25
Pernettya in Mexico and adjacent regions, Studies in the Ericales IV. Notes on Chimaphila, Gaultheria and 7
Peronospora gangliformis 3; tabacina 426
Persea borbonia 630; pubescens 486
Peru, New ferns from Bolivia and 39
Pezicula 639; acericola 59
Peziza aurantiaca 1; badia 1; domiciliana 337; vesiculosa 1
Pfeiffer, Norma E., A new variety of Isoetes virginica 411
Phacus acuminatus 85; pyrum 85
Phallus impudicus 5
Phaseolus 579; lunatus macrocarpus 59; polystachyus 250
Philadelphus 293; coronarius 291
Phlebia cervina 531
Phleum alpinum 456
Phlox glaberrima melampyifolia 128
Phlyctidium 285, 499
Phlyctochytrium 285
Pholisma 503
Pholistoma 341–345, 637; auritum 342, 343, 345, 346, 348, 349, 352; auritum arizonicum 343, 345, 346, 348; membranaceum 342, 343, 345, 346, 350, 352; racemosum 342, 343, 345, 346, 349, 350, 352
Pholistoma Lilja, The genus 341
Phoma lingam 184
Phorandendron flavescens 372, 386
Phragmidium Fragariastri 618
Phragmites communis 375, 385
Phthirusa 330

Phycomyces 331, 495, 569–572; Blakesleeanus 569
Phyllodoce glanduliflora 456
Phyllostegia 424
Phylogenetic position of the genus Jouvea (Gramineae), The morphology and 315
Phylogeny of dicotyledons, Flower buds and 287
Phymatotrichum 334; omnivorum 59, 642
Physalospora obtusa 124
Phytolacca decandra 386
Phytomonas campestris 137; flaccumfaciens 137; insidiosa 137; michiganensis 137; panici 137; stewarti 187; striafaciens 137; syringae 331
Phytophthora 180, 424
Picea 447, 449; Breweriana 257; engelmanni 216, 219; excelsa 452, 462; glabra 462; pungens 462; sitchensis 455
Pieris nitida 486
Pilosium flaccisetum 227
Pilotrichum bipinnatum 227
Pilularia 271, 272, 274–277; globulifera 275, 279; minuta 277
Pinus 167, 170–172, 442, 447, 449, 452; caribaea 254; contorta 216, 218, 219; echinata 377, 385; montana 452; monticola 55, 189, 216, 218, 219; nigra 461; ponderosa 216, 218, 219; serotina 370, 385; strobus 461, 517, 531, 646; sylvestris 461; taeda 370, 384; virginiana 377, 385
Piper 314
Pireella cymbifolia 226
Pisum sativum 125, 134
Pithecolobium 173; latifolium 173, 176
Pittosporum 155
Pityrogramma ornithopteris 57
Plant tissue culture, Controlled differentiation in a 507
Plants, Studies in Mexican and Central American plants VIII 583
Platanus 288; acerifolia 460; occidentalis 386, 460, 627; orientalis 460
Platydorina caudata 188
Plectonema wollei 78
Pleiospermium 645
Pleospora lycopersici 641
Pleurocapsa minor 78
Pleurorthotrichum 181
Plicatura lateritia 151
Pluchea camphorata 388; foetida 380, 388
Plumbagella 495
Plumbago 289; capensis 287
Pluteus admirabilis 30; fibrillosus 30; **nigrolineatus** 30; **Rhoadsii** 30
Poa pratensis 462; sandbergii 217; wrightii 455
Pocomoke Swamp: a study of a cypress swamp on the eastern shore of Maryland 367
Podophacidium 502
Pogonia ophioglossoides 125
Pogonomyces hydnoides 151
Poliotelium 174, 175; **dolichosporum** 175; **hyalospora** 175; Iresines 174, 175
Pollen analysis of a bog near Spokane, Washington 215
Pollen longevity of Ginkgo 121
Polyctenium 133
Polygala mariana 386
Polygonum 290; arifolium 373, 386; aviculare 463; hydropiperoides 373, 386; pennsylvanicum 380, 386; sagittatum 373, 386, setaceum 380, 386, virginianum 386
Polygyra thyroidus 2–5
Polymyxa graminis 499
Polyphagus euglenae 284–286
Polypodium 39; **megalolepis** 39, 40, 42; penna-marinum 44; polypodioides 372, 384
Polyporus 515; abietinus 184, 333; glomeratus 574; picipes 3, 5; Rhoadsii 152; rigidus 625–627; squamosus 1; sulphureus 1; virgatus 152; zonalis 251, 627
Polystichum 39; acrostichoides 384; aleuticum 55
Polytrichadelphus 181
Polytrichum commune 635
Pontederia cordata 375, 385
Pool, Raymond, J., Some reactions of the vegetation in the towns and cities of Nebraska to the great drought 457
Populus 461, 517; alba 461; alba bolleana 461; grandidentata 465, 468; heterophylla 370, 386; Lindgreni 467; Sargentii 460; tremuloides 534; trichocarpa 456; washoensis 465, 467, 468
Poria 515; Andersonii 574; **Rhoadsii** 33; undata 627; vincta 151; vitellina 33
Potamium vulpinum 229
Potamogeton 540; pulcher 374, 385
Potentilla 619

Preliminary experiments on Biotin 139
Preliminary notes on Hippocrateaceae, Studies of South American plants—VI. 231
Primula 290; cuneifolia 456
Production in Regnellidium, Sport 263
Proserpinaca palustris 380, 387
Protobalanus 355
Prunella vulgaris 387
Prunus lauro-cerasus 630
Psalliota 1
Psedera quinquefolia 372, 386
Pseudananas 644
Pseudocryphaea flagellifera 226
Pseudolpidium 641, 643
Pseudotsuga mucronata 216, 219; taxifolia 462
Psychotria 313; cuspidata 313
Pteridium latiusculum 378, 384
Pteris 553, 555; aquilina 466, 467; calabazensis 466, 467, 474; cretica 559, 560; cretica albo-lineata 549, 552, 554, 558–560; droogmantiana 550, 561; sulcata 549
Pteris cretica Linn. var. albo-lineata Hort., The cytology of apogamy in 549
Pterispermostrobus 298; bifurcatus 301
Ptilimnium capillaceum 387
Puccinia 175, 618, 620; **Ammophilina** 617; amphigena 618; belizensis 621; Caricis 620; cornuta 619; graminis tritici 260; **Ichnanthi** 619; inclita 619; **Nephrophyllidii** 620; riparia 620; **ripulae** 620
Pucciniastrum 58, 621; **alaskanum** 620; Gentianae 621
Pycnoporus sanguineus 151
Pyrenochaeta sacchari 420
Pyrus arbutifolia 373, 386
Pythium 258, 575, 640, 646; arrhenomanes 498; butleri 61, 133; de baryanum 55; ultimum 645

Quadrigula chodati 82
Quercus 353, 355, 358–360, 363, 466, 474, 526, 528, 536, 537, 647; agrifolia 354, 355, 360; alba 358, 376, 386, 461, 627; Applegatei 474; arizonica 359–361, 363; bicolor 357, 386, 466, 478; borealis 461; chrysolepis 355, 360; coccinea 358; douglasii 359, 360, 363; dumosa 359, 360, 363; emoryi 354, 355, 359–361, 363; engelmanni 359, 360, 363; **Eoprinus** 466, 473, 474; hypoleuca 360; ilicifolia 476; Kelloggii 466; lyrata 610; Maccanni 466, 474, 478; macrocarpa 461; Merriami 466, 476, 478; michauxii 376, 386; Muehlenbergii 474; myrtifolia 360, 361; nigra 376, 386; oblongifolia 359, 360, 363; palustris 461; phellos 376, 386; prinoides 474; prinus 466, 474; pseudolyrata 466; reticulata 359, 360, 363; rubra 386, 466, 476; spokanensis 474; spokanensis gracilis 474; stellata 361, 386; tomentella 355, 360; ursina 476; vaccinifolia 360; virginiana 359–361, 363, 629–632; virginiana geminata 357; wislizenii 360

Rachidospermum mexicanum 316
Raddia 233, 245, 246, 248, 249; impressifolia 247
Radiofilum conjunctivum 80
Radula Evansii 182
Ranunculus 293, 421; bongardi 456; cooleyae 456; cymbalaria 454; repens 454
Raouliopsis 54
Ravenelia 258
Regnellidium 264, 268, 270, 272–279, 497; diphyllum 263, 279
Regnellidium, Spore production in 263
Reif, Charles B., A new species of Tetraëdron from Minnesota 615
Reseda 288
Rhabdoderma lineare 78
Rhacopilopsis trinitensis 230
Rhamnus 187
Rhaphidorrhynchium subsimplex 227
Rhaphidostichum **guianense** 228, 229; Schwaneckianum 229
Rhexia aristosa 380, 387; mariana 380, 387; virginica 380, 387
Rhipsalis 289; rhombea 288
Rhizidiopsis emmanuelensis 285
Rhizidium mycophilum 284
Rhizobium 61, 191
Rhizochrysis limnetica 80
Rhizoctonia 184; Solani 134, 499, 646
Rhizophidium 127, 281–285, 334, 499; globosum 281; laterale 285, 334; messanensis 285; ovatum 285; sphaerocarpum 281; transversum 285
Rhizophidium. III. Germination of the resting spores. Studies on 281

Rhizopus suinus 261
Rhodea 301
Rhodobryum Beyrichianum 225
Rhododendron **idahoensis** 466, 476, 480; indicum 287; maximum 183, 466, 481; nudiflorum 373, 375, 387; viscosum 373, 387
Rhodotorula flava 572; rubra 572
Rhopis 636
Rhus copallina 378, 386; toxicodendron 372, 386
Ribes 189; bracteosum 456; petiolare 189
Riella 191
Rigidoporus surinamensis 151
Robbins, William J., Thiamin and symbiosis 569
Robbins, William J. and Mary Bartley Schmidt, Growth of excised tomato roots in a synthetic solution 193; Preliminary experiments on biotin 139
Robinia violacea 637
Rondoletia **tacanensis** 603
Rosa 288, 293; carolina 375, 376, 386
Rottboellia 319
Rozella 135
Rubus 173, 636; arcticus 456; spectabilis 456
Rudbeckia laciniata 373, 388
Ruellia ciliosa 378; ciliosa parviflora 387
Rumex occidentalis 454
Rupalleya 163
Ruppia 540
Ruschia 126
Russula 1, 4, 5, 152; **albiflavescens** 154; crustosa 152; emetica 4, 5; heterophylla 5; heterospora 152; Mariae 152; nigricans 5; pectinatoides 152; **pinetorum** 155; sericeonitens 156; subalbidula 152; **subobscura** 155; subochrophylla 152; **subsericeonitens** 156; uncialiformis 152; variata 152; virescens 4, 5; **Watsoniana** 156; Westii 155
Ruta 291
Rynchospora axillaris microcephala 385; corniculata 373, 385; glomerata 378, 385; macrostachya 376, 385; microcephala 380

Sabal 584
Saccharomyces 61
Sagittaria latifolia 375, 385
Sagraea 418
Salacia 231, 232, 241, 242, 247, 249; **acreana** 233, 243, 244; amazonica 233, 243; anomala 232, 239; **articulata** 232, 235; attenuata 232, 240; **caloneura** 233, 244; **cauliflora** 233, 246, 247; cognata 232, 233, 235; cognata egensis 235; Colasi 233, 243; congestiflora 232, 238–240; corymbosa 232, 240; **cuspidata** 233, 248, 249; **cylindrocarpa** 232, 240, 241; diffusiflora 232, 236; **divaricata** 232, 238, 239; dulcis 233, 243; gigantea 233, 247; **gracilis** 233, 249; grandiflora 247; **impressifolia** 233, 247; juruana 233, 247, 248; **Krukovii** 232, 237–239; laevigata 233, 243; laxiflora 232, 239; **lineolata** 232, 234, 235; **macrantha** 233, 245, 246; Martiana 232, 239, 240; mauritioides 232, 240; **minutiflora** 232, 236, 237; **nectandrifolia** 233, 241, 243; obovata 233, 243; obovata amazonica 243; paniculata 248, 249; **pedunculata** 232, 237; **petiolata** 233, 242, 243; podostemma 236, 237; polyanthomaniaca 233, 247, 248; **solimoesensis** 233, 247; sphaerocarpa 233, 234; Ulei 233, 243
Salix 181, 219; Capraea 512; cordata 331, 466, 470; inquirenda 468; nigra 375, 386; Schimperi 466, 468, 470; sitchensis 456
Salpiglossis 575
Salsola Pestifer 463
Salvia 333, 576
Salvinia 274–276; natans 279
Sambucus canadensis 378, 388; melanocarpa 456
Saperda tridentata 646
Saprolegnia parasitica 503
Sarcobatus vermiculatus 217
Saururus cernuus 373, 386
Saxifraga bongardi 456; bronchialis 454; nelsoniana 456
Scenedesmus abundans brevicauda 82; acutiformis 82; brasiliensis 82; perforatus 82; quadricauda maximus 82; quadricauda parvus 82; quadricauda westii 82
Schizaea 274; rupestris 278
Schizoxylon 183
Schmidt, Mary Bartley and William J. Robbins, Growth of excised tomato roots in a synthetic solution 193; Preliminary experiments on biotin 139

Schroederia judayi 82
Schuetzia 298, 302
Sciadotenia cayennensis 309; similis 308; solimoesana 309; Sprucei 308; toxifera 306–308, 314
Scirpus lineatus 385; olneyi 385; pedicellatus 380, 385
Sclerospora graminicola 187
Sclerotinia 578; fruticola 578
Sclerotium delphinii 131; rolfsii 56
Scolopendrium vulgare 561
Scolytus 261
Scopella 500
Scrophularia nodosa 440
Scutellaria 422
Scylla 333
Scytinotus concolor 160
Secondary vascular tissues of the oaks indigenous to the United States—I. The importance of secondary Xylem in delimiting Erythrobalanus and Leucobalanus 353
Seedbearing fructification from the Mississippian of Pennsylvania and Virginia, Lagenospermum imparirameum sp. nov., a 297
Selaginella 275; apoda 377, 384
Selenastrum bibraianum 82
Selenia dissecta 637
Sematophyllum caespitosum 228; loxense 228
Senecio 251; aureus 388; tomentosus 388
Septoria bromigena 635; graminum 259
Sequoia 167; gigantea 637; sempervirens 637
Setaria 187
Seubertia 163
Shortia 291
Silene pennsylvanica 386
Simmondsia californica 254
Sisyrinchium 186; gramineum 385
Sium cicutaefolium 375, 387
Skierka 579
Smelowskia 133
Smilacina 546
Smilax hispida 385; lanceolata 385; laurifolia 372, 385; rotundifolia 385; tamnifolia 385; Walteri 372, 385
Smith, A. C., Studies of South American plants—VI. Preliminary notes on Hippocrateaceae 231
Smith, A. C. and B. A. Krukoff, Notes on the botanical components of Curare—II 305
Smith, Helen V., A flora of eastern American aspect in the miocene of Idaho 465
Smith Island, N. C., A new forest climax: the salt spray climax of 629
Snail Polygyra thyroidus as a mycophagist, The 1
Sobralia 190
Solanum 422; tuberosum 333; valdiviense 501
Solidago bicolor 330; fistulosa 380, 388; rugosa 388; tenuifolia 380, 388
Some incorrectly described Asclepiads 605
Some new Myxophyceae from southern California 489
Some reactions to the vegetation in the towns and cities of Nebraska to the great drought 457
Sorastrum americanum 82
Sorbus 334; sitchensis 456
Sorghum 251
Soromanes integrifolia 51
Soutellaria 576
South American plants—VI. Preliminary notes on Hippocrateaceae, Studies of 231
Sphaceloma rosarum 125
Sphacelotheca sorghi 137, 503
Sphaerocarpos 185, 191
Sphaerotheca castagnei 3
Sphaerozoma excavatum subquadratum 84
Spiranthes cernua 380, 386; gracilis 386; michuacana 504
Spirea tomentosa 380, 386; Vanhouteii 462
Spirechina 173; Loesneriana 173
Spirogyra 131, 580; orientalis 82
Spirulina laxissima 78
Spore production in Regnellidium 263
Sporobolus neglectus 464; vaginiflorus 464
Sporocybe azalyeae 637
Stachys rigida 183; tenuifolia 387
Stagonospora 256
Staphidium 418
Staurastrum contortum 84; curvatum 84; cuspidatum canadense 84; cuspidatum cornulatum 84; longispinum 84; longispinum bidentatum 84; megacanthum scoticum 84; ophiura 84; paradoxum

longipes 84; pentacerum 84; rotula 84; sublaevispinum 84
Steblotrichum 97, 101
Steere, William Campbell, Barbula in North America north of Mexico 93
Stelis 53
Stellaria longipes 456
Stemonitis fusca 126
Stenotaphrum 319
Stereocaulon 186
Stereophyllum leucostegium 227; radiculosum 227
Stereum 515, 521, 523, 525, 527, 529, 532; abietinum 517, 519, 520; albobadium 518–520, 537; ambiguum 517, 520; Burtianum 516, 518, 520, 522; Chailletii 517, 519, 522; cinerascens 518, 519, 522, 528; diaphanum 516, 518, 522, 524; elegans 151; erumpens 518; fasciatum 518–520, 524, 528, 530, 535; frustulosum 516, 517, 519, 526, 528, 536; fuscum 518–520, 526; gausapatum 516, 518–520, 528, 530, 535, 639; hirsutum 518, 519, 524, 526, 530; insigne 536; lobatum 151; Murrayi 517, 519, 520, 524, 530, 536; ochraceoflavum 518, 519, 526, 531, 533; Pini 517, 519, 520, 531; purpureum 517, 519, 526, 532, 534; radiatum 517, 519, 528, 532; rameale 518–520, 526, 528, 533; roseocarneum 518, 519, 522, 533; rufum 517, 519, 526, 534; rugisporum 517; rugosiusculum 517, 519, 534; rugosum 517–519, 522, 534; sanguinolentum 516, 517, 519, 524, 535; sepium 536; sericeum 518, 519, 522, 526, 535; subpileatum 516, 518, 519, 522, 535; sulcatum 517, 519, 526, 536; versiforme 518, 519, 524, 537; umbrinum 518–520, 536
Stereum in Pennsylvania, The genus 515
Stevensea Wrightii 332
Stewartia 647
Stictis herbacea 4, 5
Stigmatopteris 48, 49; caudata 48; guianensis 48; opaca 48; rotundata 48; varians 48, 49
Stipitococcus urceolatus 78
Streptanthus 130
Streptopus amplexifolius americanus 456
Stropholirion 163, 165
Strophostyles umbellata 386
Structure and development of the apical meristem in the shoots of Taxodium distichum, The 431
Struthantus 330
Struthiopteris 39; brasiliensis 43; Buchtienii 44; penna-marina 44
Strychnos 231, 306, 307, 311–314; Crevauxiana 311; Curare 311; depauperata 311; guianensis 311, 313; Jobertiana 306, 312; Mitscherlichii 306, 313; Mitscherlichii pubescentior 313; Peckii 306, 307, 312, 313; toxifera 307, 310, 314; trichostyla 312
Studies in the Ericales IV. Notes on Chimaphila, Gaultheria and Pernettya in Mexico and adjacent regions 7
Studies in the Uredinales, the genus Maravalia 173
Studies of Mexican and Central American plants VIII 583
Studies of South American plants—VI. Preliminary notes on Hippocrateaceae 231
Studies on Rhizophidium. III. Germination of the resting spores 281
Styrax 646; argenteus 601; magnus 600, 601
Succinea putris 3
Symbiosis, Thiamin and 569
Symphytum officinale 3
Symplocos prionophylla 601; pycnantha 601; tacanensis 601
Syringia vulgaris 3
Syrrhopodon 119; floridanus 100; incompletus 223; ligulatus 223; prolifer 223; rigidus 223; texanus 100, 119

Tabebuia pallida 421
Tacca 540
Taft, Clarence E., Additions to the algae of Michigan 77
Tagetes erecta 617
Tamarix 292
Taphrina 127, 130, 337, 425, 499; aceris 127; lethifera 127; robinsoniana 337; sacchari 256
Taraxacum erythrospermum 462; officinale 454, 462
Taxithelium planum 230
Taxodium 167, 170, 171, 432, 433, 437—440, 442, 445, 447, 449–451; ascendens 167,

385, 486; distichum 91, 167, 370, 382, 385, 421, 431, 432, 437–439, 449, 450, 452, 625, 627
Taxodium distichum, A note on the morphology of the deciduous shoot of 167
Taxodium distichum, The structure and development of the apical meristem in the shoots of 431
Taxonomy and ecology of Agropyron spicatum and A. inerme, The 327
Tecoma radicans 372, 387
Telangium 302; Calymmatotheca 302
Telipogon 134
Tellima grandiflora 456
Ternstroemia **impressa** 599, 600
Tetmemorus brebissonii 84; granulatus 84; granulatus attenuatus 84
Tetraëdron 615; caudatum 82; caudatum incisum 82; enorme 82; gigas granulatum 82; **grande** 615, 616; quadricuspidatum 615; minimum scrobiculata 82; regulare 615; tortum 615; trigonum papilliferum 82
Tetraëdron from Minnesota, A new species of 615
Thalictrum polygamum 373, 386
Thelephora 515
Theobroma 293; Cacao 291
Thermophila 233, 244, 245
Thiamin and symbiosis 569
Thielavia basicola 256
Thlaspi arvense 463
Thrixspermum 192
Thuja 462; plicata 216
Thyronectria denigrata 128, 338
Tibouchina capitata 415; **cornuta** 415; membranifolia 415
Tigridia 539
Tilia 291; europaea 461; glabra 461
Tilletia laevis 578; levis 60; tritici 60
Tinnantia 539, 545; fugax 540, 545
Tomato roots in a synthetic solution, Growth of excised 193
Tontelea 232, 241–243
Tortula 93, 96, 97, 113, 571; acuta 96, 107; agraria 96; Closteri 101; Cruegeri 101; cylindrica 102; Donnellii 103; elata 105; fallax 107, 119; marginata 97; rigidula 112; spadicea 113; vinealis 116
Torula 189
Toumeya 189
Toxicaria americana 311
Trachelomonas hispida 85: hispida coronata 85; hispida punctulatum 85; volvocina 85
Tradescantia 124, 190, 539, 540, 638; fluminensis 181; geniculata 540; mytrifolia 540; paludosa 137, 192
Tragopogon dubius 250
Trametes Pini 59
Tranzschelia pruni-spinosae 333
Trapa microphylla 331
Traquaria 275
Trees, Two pocket rots of hardwood 625
Tribulus terrestris 463
Trichoglottis 192
Tricholoma 1, 155; humile 1
Trichomanes Boschianum 132
Trichostelium ambiguum 230
Trichostomum 104, 112; Ehrenbergii 104; indigens 107
Trifolium pratense 4, 5
Trillium 189, 251, 424; erectum 60, 648; erectum Blandum 334; sessile 374, 385
Triphyllopteris 301
Tripsacum 319; dactyloides 422
Trisetum pennsylvanicum 376, 385
Triteleia 163–166; grandiflora 163
Triticum 186, 337; aegilopoides 502; monococcum 503; vulgare 337
Tropaeolum 291
Tryblidiella 647
Tsuga 535; heterophylla 216, 219, 455; mertensiana 216, 455
Turpinia occidentalis 599; **tricornuta** 598
Two pocket rots of hardwood trees 625
Tylopilus peralbidus 33
Typha angustifolia 385; latifolia 375, 380, 385

Ulmus 479; alata 466, 476, 479; americana 460; Brownelli 479; crassifolia 479; fulva 460; Moorei 479; parvifolia 461, 479; **paucidentata** 466, 476, 478, 480; pumila 479; racemosa 480; Tanneri 479
Uncinula australiana 4, 5
Uniola 317, 324; paniculata 632
United States—I. The importance of secondary Xylem in delimiting Erythrobalanus and Leucobalanus, Secondary vascular tissues of the oaks indigenous to the 353
Uredinales, New and unusual species of 617

Uredinales, the genus Maravalia, Studies in the 173
Uredinopsis 126, 183
Uredo Ammophilae 618; Ammophilina 617, 618; **detenta** 621
Urnula Geaster 578
Uromyces 175, 620; achrous 176; elatus 175, 176; pressus 177
Uronema elongatum 80
Urtica procera 386
Ustilago avenae 137; crameri 192; Lordei 638; nigra 638; zeae 640

Vaccinium 375, 378; atrococcum 387; caespitosum 456; corymbosum 387; ovalifolium 456; oxycoccus 454; uliginosum 456; virgatum 387
Valeriana sitchensis 456
Vallisneria spiralis 640
Valonia 60
Vaucheria 85
Vegetation in the towns and cities of Nebraska to the great drought, Some reactions to the 457
Venenarius **Rhoadsii** 30, 37; solitariiformis 31
Venturia inaequalis 61
Veratrum nigrum 539
Verbascum 293; Thapsus 291
Verbena hastata 641
Vernonia 178, 581; Deppeana 178; noveboracensis 378, 380, 388; patens 178
Veronica alpina 456
Vesicularia amphibola 230
Vibrio amylocella 638
Viburnum 375; cassinoides 373, 388; **chiapense** 603, 604; dentatum 373, 388; disjunctum 604; jucundum 604; nudum 373, 388; Opulus 451; prunifolium 373, 388; rufidulum 451
Vincetoxicum 613; suberosum 612
Viola 378; cucullata 374, 387; glabella 456; lanceolata 387; langsdorfii 456; pedata 387; primultifolia 387
Virginia, Lagenospermum imparirameum sp. nov., a seedbearing frutification from the Mississippian of Pennsylvania and 297
Viticella aurita 346; racemosa 349
Vitis 372; labrusca 387; rotundifolia 372, 387

Washington, Pollen analysis of a bog near Spokane, 215
Weatherwax, Paul, The morphology and phylogenetic position of the genus Jouvea (Gramineae) 315
Wells, B. W., A new forest climax: the salt spray climax of Smith Island, N. C. 629
Went, F. W., Further analysis of the pea test for auxin 391
White, Philip R., Controlled differentiation in a plant tissue culture 507
Williams, Simon, Secondary vascular tissues of the oaks indigenous to the United States—I. The importance of secondary Xylem in delimiting Erythrobalanus and Leucobalanus 353
Wimmeria 129
Wolf, Fred T. and Frederick A. Wolf, The snail Polygyra thyroidus as a mycophagist 1
Wolf, Frederick A. and Fred T. Wolf, The snail Polygyra thyroidus as a mycophagist 1
Wolffia columbiana 422
Wolffiella lingulata 187
Woodsia oregana 53

Xanthidium armatum fissum 84; armatum irregularis 84; cristatum uncinatum 84; torreyi 84
Xanthium Pennsylvanicum 580
Xenococcus endophytica 493; **pulcher** 491, 492
Xenotheca 298
Xyris caroliniana 380, 385

Yucatan, A new species of Cuscuta from 623
Yuncker, T. G., A new species of Cuscuta from Yucatan 623

Zannichellia 540
Zea 579; mays 645
Zeuxine strateumatica 635
Zinnia elegans 4, 5
Zinowiewa 129
Zizania aquatica 376, 385
Zonites nitidulus 1
Zygnema carinatum 82; synadelphum 82
Zygnemopsis minutum 82
Zygorhizidium Willei 285
Zygotrichia cylindrica 102

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